

Prepared for



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Carus Chemical Company**

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**U.S. Environmental Protection
Agency Region 5**

77 West Jackson Boulevard
Chicago, Illinois 60604

FINAL REMEDIAL INVESTIGATION REPORT

MATTHIESSEN AND HEGELER ZINC COMPANY SITE
LASALLE, ILLINOIS

Volume 1 of 6

Prepared by



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Geosyntec Project Number CWR1710

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REMEDIAL INVESTIGATION REPORT**

REVISION 0

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LA SALLE COUNTY, ILLINOIS**

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Region 5
77 West Jackson Boulevard
Chicago, Illinois 60604**

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Appendix RA Final Risk Assessment

ACRONYMS AND ABBREVIATIONS

µg/kg	Microgram per Kilogram
µg/L	Microgram per Liter
µg/m ³	Microgram per Cubic Meter
µm	Micron or Micrometer
ABS	Activity-Based Sampling
ADD	Average Daily Dose
AE	Assessment Endpoint
AES	Atomic Emission Spectroscopy
AL	Action Level
ALM	Adult Lead Model
ANOVA	Analysis of Variance
AOC	Administrative Order on Consent
ASAOC	Administrative Settlement Agreement and Order on Consent
ASO	Abandoned Sewer Outfall
AST	Aboveground Storage Tank
ASTM	American Society for Testing and Materials International
ATSDR	Agency for Toxic Substance and Disease Registry
ATV	All-Terrain Vehicle
AVS	Acid Volatile Sulfides
BAR	Biological Assessment Report
BERA	Baseline Ecological Risk Assessment
bgs	Below Ground Surface
BTAG	US EPA Region 9 Biological Technical Assistance Group
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
BTV	Background Threshold Value
CalEPA	California Environmental Protection Agency
Carus	Carus Chemical Company

ACRONYMS AND ABBREVIATIONS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
cm	Centimeter
cm/s	Centimeter per Second
COC	Constituent of Concern
COI	Chemicals of Interest
Consensus Document	“Technical Approach Consensus Document, Human Health and Ecological Risk Assessments”
COPC	Constituent of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CRQL	Contract-Required Quantitation Limit
CSM	Conceptual Site Model
CSO	Combined Sewer Overflow
CTE	Central Tendency Exposure
cVOC	Chlorinated Volatile Organic Compound
CWA	Clean Water Act
DCE	Dichloroethene
DO	Dissolved Oxygen
DQO	Data Quality Objective
Ds	Simpson’s Index of Diversity
EA	Exposure Area
EF	Exposure Frequency
ELCR	Excess Lifetime Cancer Risk
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ESL	Ecological Screening Level (US EPA Region 5)
ERT	Emergency Response Team

ACRONYMS AND ABBREVIATIONS

ESV	Ecological Screening Value
ET	Exposure Time
f/cc	Fiber per Cubic Centimeter
Fibers/mL	Fibers per Milliliter
FCM	Food Chain Model
fIBI	Fish Community Index of Biotic Integrity
FIELDS	Field Environmental Decision Support
FS	Feasibility Study
FSP	Field Sampling Plan
ft ²	Square Foot
ft/ft	Foot per Foot
g/cc	Grams per Cubic Centimeter
Geosyntec	Geosyntec Consultants
GPM	Gallons per Minute
GPS	Global Positioning System
GWSV	Groundwater Screening Value
H'	Shannon Weiner Diversity Index
HEAST	Health Effects Assessment Summary Table
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
I&M	Illinois and Michigan
IBI	Index of Biotic Integrity
ICP	Inductively Coupled Plasma
ICRR	Illinois Central Railroad
IDNR	Illinois Department of Natural Resources

ACRONYMS AND ABBREVIATIONS

IDPH	Illinois Department of Public Health
IEPA	Illinois Environmental Protection Agency
IEUBK	Integrated Exposure Uptake Biokinetic Model
IRIS	Integrated Risk Information System
IRSL	Industrial Regional Screening Level
ISGS	Illinois State Geological Survey
ISO	International Organization for Standardization
IURLTL	Less-Than-Lifetime Inhalation Unit Risk
IUR	Inhalation Unit Risk
IWQS	Illinois Water Quality Standard
K_d	Potential for Adsorption
K_H	Henry's Law Constant
K_{OC}	Adsorption Coefficient for Organic Carbon
K_{OW}	Octanol-Water Partition Coefficient
LNAPL	Light Non-Aqueous Phase Liquid
LOAEL	Lowest Observed Adverse Effects Level
LRM	LaSalle Rolling Mill
LVR	Little Vermilion River
MBI	Macroinvertebrate Biotic Integrity
MCE	Mixed Cellulose Ester
MCL	Maximum Contaminant Level
mIBI	Macroinvertebrate Community Index of Biotic Integrity
MEK	2-Butanone (Methyl Ethyl Ketone)
mg/kg	Milligram per Kilogram
mg/L	Milligram per Liter
mm	Millimeter
MOU	Memorandum of Understanding

ACRONYMS AND ABBREVIATIONS

MRL	Minimal Risk Level
MS	Matrix Spike
MSD	Matrix Spike Duplicate
msl	Mean Sea Level
mV	Millivolt
MW	Monitoring Well
NAD	North American Datum
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NIOSH	National Institute for Occupational Safety and Health
NOAEL	No Observable Adverse Effects Level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRCS	Natural Resource Conservation Service
NRWQC	National Recommended Water Quality Criteria
NWI	National Wetland Inventory
OCL	Organochlorine
ORP	Oxidation Reduction Potential
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
OU1	Operable Unit 1
OU2	Operable Unit 2
Pmc	Bond Formation of the McLeansboro Group
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene
PDC	Pyridine Dicarboxylic Acid

ACRONYMS AND ABBREVIATIONS

PEC	Probable Effects Concentration
PID	Photoionization Detector
PPE	Personal Protective Equipment
ppm	Part per Million
ppmv	Part per Million by Volume
PPRTV	Provisional Peer Reviewed Toxicity Value
PRG	Preliminary Remediation Goal
PRP	Potentially Responsible Party
PSI	Preliminary Site Investigation
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl Chloride
Qaf	Quaternary Age (Late Holocene) Artificial Fill
QAPP	Quality Assurance Project Plan
QC	Quality Control
Qe	Equality Formation of the Quaternary System
Qly	Lemont Formation of the Quaternary System
RA	Risk Assessment
RAC	Remedial Action Contract
RAFS	Releasable Asbestos Field Sampler
RAGS	Risk Assessment Guidance for Superfund
RAT	Rapid Assessment Tool
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RO	Remediation Objective
ROD	Record of Decision

ACRONYMS AND ABBREVIATIONS

RRSL	Residential Regional Screening Level
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SB	Soil Boring
SEM	Simultaneously Extracted Metals
SEP	Sequential Extraction Procedure
SF	Slope Factor
SLERA	Screening Level Ecological Risk Assessment
SMDP	Scientific Management Decision Point
SOP	Standard Operating Procedure
SOW	Statement of Work
SPLP	Synthetic Precipitation Leaching Procedure
SSI	Screening Site Inspection
SSL	Soil Screening Level
START	Superfund Technical Assessment and Response Team
SU	Standard Unit
SV	Screening Value
SVOC	Semivolatile Organic Compound
SW ESV	Surface Water Ecological Screening Value
SWSV	Surface Water Screening Value
TACO	Tiered Approach to Corrective Action Objectives
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TEC	Threshold Effects Concentration
TEM	Transmission Electron Microscopy
TOC	Total Organic Carbon

ACRONYMS AND ABBREVIATIONS

TR	Target Risk
TRV	Toxicity Reference Value
UCL	Upper Confidence Limit
URF	Unit Risk Factor
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
US EPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
VC	Vinyl Chloride
VDEQ	Virginia Department of Environmental Quality
VF	Volatilization Factor
VOC	Volatile Organic Compound
WA	Work Assignment
WBZ	Water-Bearing Zone
Weston	Weston Solutions, Inc.
XRF	X-Ray Fluorescence

EXECUTIVE SUMMARY

The Matthiessen and Hegeler Zinc Company Site (Site) located in LaSalle, LaSalle County, Illinois, is a former zinc smelting and rolling facility listed on the National Priorities List (NPL). The United States Environmental Protection Agency (US EPA) and the potentially responsible parties (PRP) are addressing the Site through a remedial investigation (RI) and feasibility study (FS). This RI report presents the results of the RI as required under an Administrative Settlement Agreement and Order on Consent (ASAO), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Docket No. V-W-06-C-856 dated October 6, 2006, between US EPA Region 5 and Carus Corporation and Carus Chemical Company (Carus). This report characterizes the nature and extent of risks posed by the Site and documents the data collection efforts and analyses performed that will support the preparation of the FS.

For the RI/FS, the Site was divided into two operable units (OU). On OU1, Geosyntec Consultants (Geosyntec) is conducting RI/FS activities on behalf of Carus. On OU2, US EPA's contractor, SulTRAC, is conducting RI/FS activities. This RI report was prepared jointly by Geosyntec and SulTRAC.

OU1 occupies about 47 acres and was divided into three areas for the RI: the Carus Plant Area, the Slag Pile Area, and the Little Vermilion River (LVR). For over 90 years and continuing today, the Carus Plant has manufactured potassium permanganate and other specialty chemicals. These operations are not related to the contamination under investigation. The main feature in the Slag Pile Area is a waste pile, approximately 3,000 feet (ft) long and 80 to 90 ft tall, resulting from the former smelting operations of the Matthiessen and Hegeler Zinc Company. The Slag Pile Area generally trends north to south between the Carus Plant and OU2 on the west and the LVR on the east. The LVR flows along the eastern edge of the Slag Pile Area and the eastern and northern edges of OU2 and forms the eastern boundary of the Site. The LVR is a tributary to the Illinois River approximately one mile south of the Site.

OU2 occupies about 180 acres. Its central feature is the former production area of the Matthiessen and Hegeler Zinc Company, which included zinc smelting, a Rolling Mill, and ancillary operations. From 1858 to the early 1960's, smelting of zinc ores and other industrial operations occurred on OU2. After the early 1960's, the Rolling Mill operated until 2000. OU2 includes approximately 150 buildings and structures formerly used for industrial operations, shallow slag and sinter piles that heterogeneously cover the former production area, several abandoned and closed mine shafts, and an undeveloped woodland. OU2 also includes surrounding off-site residential or undeveloped areas. The main, contiguous portion of

OU2 is bounded to the west by residences and parks, to the south by the Carus manufacturing facility, to the east by the Slag Pile and the LVR and to the north by the LVR and undeveloped or industrial property.

The Site is underlain by Pennsylvanian bedrock consisting of shale, limestone, and thin coal beds. This bedrock is low hydraulic conductivity and generally not a water-producing unit. The bedrock is overlain by glacial till and lakebed deposits, alluvial deposits along the LVR valley, and man-made fill consisting of reworked soil, wastes and debris from the zinc smelting operations. The hydraulic conductivity of these overlying deposits is variable but generally higher than the bedrock units.

Two water-bearing zones (WBZs) are found on Site. WBZ1 consists of the till, lakebed, and alluvial deposits and the various fill materials. WBZ2 consists of the Pennsylvanian bedrock. Groundwater gradients in both WBZ1 and WBZ2 trend to the east and southeast, toward the LVR.

Site samples were compared to screening values (SV) to establish chemicals of interest (COI). Soil and solid matrix samples were screened against Residential Regional Screening Levels (RRSL), Industrial Regional Screening Levels (IRSL) and Background Threshold Values (BTV) for surface and subsurface soil. Groundwater samples were screened against Tap Water Regional Screening Levels and Federal Maximum Contaminant Levels (MCL). Sediment samples were screened against ecological screening values (ESV). Surface water samples were screened against Surface Water (SW) ESVs.

The RI documented (based on RI investigations between 2007 and 2009 as well as pre-RI investigations in the early 1990's) exceedances of SVs in soils and solid matrix, sediment, surface water, and groundwater samples. Soil and solid matrix samples exhibiting exceedances included surface and subsurface soil samples and, at OU2, building materials and shallow piles. Sediment sample exceedances were limited to OU1, primarily in the LVR. Surface water samples exceeded screening levels in the LVR and also in intermittent streams and other areas of standing water on OU2. Groundwater was present site-wide, with exceedances of screening levels in both WBZ1 and WBZ2.

Metals contamination was present site-wide, and included exceedances of SVs for the following metals:

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Manganese
- Mercury
- Nickel
- Selenium
- Silver
- Thallium
- Vanadium
- Zinc

Concentrations of metals exceeded screening levels in all media sampled, except air.

Other contaminants exceeded SVs, although generally in fewer media, in more discrete areas of the Site and with less frequency compared to metals. Cyanide exceeded SVs in limited surface water and sediment samples. Volatile organic compounds (VOCs) exceeded SVs in a few discrete groundwater sample locations and in sediment samples. Semivolatile organic compounds (SVOCs) were greater than SVs in surface and subsurface soil samples, building materials, OU2 piles, sediment, and groundwater. Polychlorinated biphenyls (PCBs) exceeded SVs in surface and subsurface soils, OU2 piles, and sediment. Pesticides exceeded SVs in OU2 piles, groundwater (OU2 only), sediment (OU1 only), and surface water (OU2 only). Asbestos exceedances were limited to OU2 and were found to exceed screening levels in surface soil, building materials, and shallow piles. In a few instances, these exceedances were based solely on pre-RI samples that were not replicated by RI samples (e.g., cyanide and in some media, PCBs or pesticides) or were for a single analyte (e.g., acetone in sediment).

The mobility of the contaminants present on Site varies with the different media. Soil and solid matrix contamination may enter surface water as eroded materials transported by surface runoff. Infiltration may mobilize soil contaminants to groundwater. Many of the contaminants strongly sorb to soil particles and may be transported as suspended sediment. Soil and solid matrix contamination may also become airborne as fugitive dust where bare soil or waste materials are present. Asbestos, present on OU2, is a potential airborne contaminant.

The contaminants present in the sediment may be transported as suspended sediment, or may dissolve into the surface water and be transported as dissolved contaminants. Additionally, infiltration through contaminated sediment may result in migration to groundwater.

Surface water could carry suspended sediment or dissolved contamination. Infiltration of contaminated surface water into the ground could also result in migration of contaminants to groundwater.

The presence of contaminants in groundwater at concentrations above the screening levels indicates the contamination is potentially mobile. The gradients in the groundwater indicate flow toward the east and southeast, potentially discharging into the LVR. Physiochemical changes upon discharge into surface water can result in precipitation of some contaminants, resulting in contamination of the sediments at those locations.

A human health risk assessment (HHRA) was prepared for the Site calculating cancer and non-cancer risks based on the site-specific data and consistent with US EPA risk assessment guidance. Because of the number of exposure area/pathway combinations evaluated in the risk assessment, summarizing the results is challenging, but some broad generalizations are possible. The risk assessment calculated cancer risks from exposure to soils that are generally within or below the US EPA acceptable risk range, with the exception of future residential exposure and, for some areas of the Site, future commercial/industrial exposure. Even though the current and former industrial areas of the Site have not historically been used for residential purposes and are not currently zoned for residential use, risks associated with future residential use in those areas were calculated. In some exposure area/pathway combinations, these calculations also ignored pavement and buildings that restrict direct contact with soil contamination. The calculated cancer risks are generally driven by metals, PAHs, PCBs, and asbestos, depending on the area of the Site. Site-wide non-cancer risks are generally above a hazard index (HI) of 1 based on the presence of metals. For each pathway, metals were assumed to be in their most mobile or toxic form, even though indirect data indicated less mobile or toxic forms were likely present and even though this approach resulted in conflicting assumptions for different pathways. Site-wide groundwater has the potential for risks to exceed US EPA's acceptable risk range, particularly if used as a drinking water source, although all groundwater use at the Site is currently prohibited by law. Risks from exposure to groundwater are driven primarily by metals. Risks from possible fish ingestion or direct contact with the LVR are within the US EPA acceptable risk range.

An ecological risk assessment (ERA) was also prepared consistent with US EPA guidance. A screening level ERA (SLERA) was conducted for each ecological exposure area to determine whether a more detailed assessment was necessary. At the Carus Plant and Slag Pile Area on OU1 and the Main Plant Area on OU2, concentrations of several constituents, primarily metals, PAHs, PCBs, and pesticides exceed ESVs, which is the SLERA metric for predicting potential adverse effects to terrestrial receptors. In addition, the poor quality substrate (lack of soil) and poor quality/limited vegetation indicate adverse

ecological effects. It is unlikely that the potential for ecological risk predicted by the SLERA can be attributed to the conservative assumptions or inherent uncertainties. Further, each of these areas has been developed and used for heavy industrial operations for decades and provides limited ecological habitat. The Carus Plant is expected to continue in use for active chemical manufacturing operations for the foreseeable future, and although the future use of the Slag Pile and Main Plant Areas has not been determined, the poor quality/limited habitat is unlikely to support populations of ecological receptors under current or reasonably anticipated future conditions. Therefore, the Carus Plant and Slag Pile Area of OU1 and the Main Plant Area of OU2 did not warrant further evaluation in a baseline ecological risk assessment (BERA). However, to further evaluate potential risks predicted by the SLERA, a BERA was prepared for the LVR and terrestrial areas of OU2 that might provide suitable ecological habitat. Together, the multiple lines of evidence evaluated in the LVR BERA support that the Site is not having a significant effect on the overall health of the ecological community. There were some measurement endpoints in the LVR BERA that suggested the possibility of limited effects; however, these were either not consistently observed, difficult to attribute to contaminants, and/or based on conservative assumptions. Risk management actions to reduce on-going contributions of contaminants from Site features to the LVR (e.g., erosion and storm water runoff control for the Slag Pile and control of inputs from the abandoned sewer outfall [ASO]) would further reduce chemical concentrations and, thus, further mitigate potential ecological risks. The LVR BERA indicates there are no unacceptable risks to ecological receptors in or associated with the LVR. The BERA showed potential risks to ecological receptors in terrestrial portions of OU2. Terrestrial receptor risks were driven primarily by metals in soils.

The data developed for this RI is generally adequate to characterize and delineate the conditions present on-site with some minor limitations. Some data limitations and uncertainties remain with regard to investigation of specific areas of the Site or specific analytical parameters. In most cases, these were addressed by adopting assumptions in the risk assessments that resulted in conservative determinations of risk for the pathways considered. The remaining limitations and uncertainties may be addressed as part of the FS or subsequent remedial design.

1.0 INTRODUCTION

The Matthiessen and Hegeler Zinc Company Site located in LaSalle, LaSalle County, Illinois, is a former zinc smelting and rolling facility currently listed on the NPL as a US EPA Superfund Site in Region 5 (US EPA 2008a). US EPA and the PRPs currently are addressing the contamination at the Matthiessen and Hegeler Zinc Company Site through a RI and FS. The Matthiessen and Hegeler Zinc Company Site consists of two OUs, OU1 and OU2. The PRPs include Carus. OU1 is a PRP-lead site where the PRP consultant, Geosyntec, is conducting RI activities. OU2 is an US EPA Superfund-lead site where SulTRAC is conducting RI activities. SulTRAC also is conducting split sampling and oversight of the PRP RI/FS activities. The long-term cleanup of the Matthiessen and Hegeler Zinc Company Site is being addressed under US EPA's Superfund Division's remedial process.

This RI report is required under an ASAOC, CERCLA Docket No. V-W-06-C-856 dated October 6, 2006, between US EPA Region 5 and Carus. Under the ASAOC, Carus agreed to perform the RI/FS on the portion of the Matthiessen and Hegeler Zinc Company Site that it currently owns, OU1, as well as on the LVR. Geosyntec, the PRP consultant, is providing PRP technical support for OU1 activities. US EPA concurrently is conducting the RI/FS on the remainder of the Matthiessen and Hegeler Zinc Company Site and in adjacent residential areas. Additionally, under US EPA Remedial Action Contract (RAC) II for Region 5, Contract No. EP-S5-06-02, Work Assignments (WA) No. 015-RSBD-B568, 115-RSBD-B568, 016-RICO-B568, 032-RICO-B568, and 132-RICO-B568, US EPA's contractor, SulTRAC, is providing oversight and technical support for RI/FS-related activities, including preparation of this Final RI Report.

As mandated by the ASAOC, this RI report is a combined PRP-lead (OU1) and Superfund-lead (OU2) report written as one document. The PRP is responsible for final production of this report. SulTRAC and Geosyntec have prepared this combined RI report to present Matthiessen and Hegeler Zinc Company Site data collected to date during sampling activities and from data interpretation and risk assessments. SulTRAC has also performed split sampling and oversight on OU1 RI/FS activities performed by Geosyntec. This RI report presents data collected from the entire Matthiessen and Hegeler Zinc Company Site needed to characterize physical site conditions, establish the nature and extent of contamination, evaluate the fate and transport of contaminants, and ultimately evaluate the risk levels posed by the Matthiessen and Hegeler Zinc Company Site to human health and the environment.

The following sections discuss the purpose of the report ([Section 1.1](#)), the Site background ([Section 1.2](#)), and the report organization ([Section 1.3](#)).

1.1 PURPOSE OF REPORT

The purpose of the RI report is to characterize the nature and extent of risks posed by the Matthiessen and Hegeler Zinc Company Site. As such, the RI report provides an evaluation of the chemicals of concern and a determination of whether current or past operations have resulted in the release or threatened release of hazardous substances that may pose a threat to human health or the environment. The RI report presents the information obtained during the RI, including: 1) the geology and hydrology of the Site; 2) the nature and extent of the contamination at or from the Site; and 3) all ecological zones, including terrestrial, riparian, wetlands, aquatic/marine, and transitional zones.

The roles of the parties involved and the integration of the OU1 and OU2 investigations are discussed below.

1.1.1 Roles of Parties Involved

The primary parties and their roles in implementing the RI/FS for the Matthiessen and Hegeler Zinc Company Site include:

- US EPA – The primary agency responsible for investigation and potential remediation of the Matthiessen and Hegeler Zinc Company Site. US EPA is responsible for 1) the Superfund-lead RI/FS activities for OU2 (technical assistance provided by SulTRAC); and 2) providing oversight for OU1, which is being implemented by Carus.
- Illinois Environmental Protection Agency (IEPA) – Agency of the State of Illinois responsible for coordinating with US EPA on the investigation and potential remediation of the Matthiessen and Hegeler Zinc Company Site.
- SulTRAC – The contractor designated by US EPA to provide: 1) technical support for all OU2 RI/FS activities; and 2) oversight of the OU1 RI/FS activities; and 3) split sampling of OU1 samples.
- Carus Corporation – One of two respondents to the ASAOC responsible for implementing the RI/FS for OU1. Carus Corporation and Carus Chemical Company are referred to collectively in this report as “Carus”.

- Carus Chemical Company – A wholly-owned subsidiary of Carus Corporation and one of two respondents to the ASAO responsible for implementing the RI/FS for OU1. Carus Corporation and Carus Chemical Company are referred to collectively in this report as “Carus”.
- Geosyntec – The contractor designated by Carus to provide technical support for OU1 RI/FS activities.

1.1.2 Integration of OU1 and OU2 Investigations

US EPA, SulTRAC, Carus, and Geosyntec have worked cooperatively during the RI fieldwork and in preparing this report to jointly produce one comprehensive RI/FS for the entire Matthiessen and Hegeler Zinc Company Site. To the extent possible, the RI/FS activities for OU1 and OU2 were coordinated to: 1) allow for oversight by SulTRAC of the OU1 RI/FS activities conducted by Geosyntec; 2) allow for split sampling of OU1 RI/FS sampling activities; and 3) collect groundwater and water level data concurrently so that data could be evaluated on a site-wide basis.

1.2 SITE BACKGROUND

The Site description, history, and previous investigations are discussed below.

1.2.1 Site Description

The Matthiessen and Hegeler Zinc Company Site is located in LaSalle, LaSalle County, Illinois. The entire Site occupies about 227 acres and includes inactive primary zinc smelting operations and associated abandoned buildings, a former Rolling Mill, and the active Carus facility and its property (Figure 1.2.1-1). The Matthiessen and Hegeler Zinc Company Site is bound by the LVR to the north and east and by private residences to the south and west. Tracts of farmland and a limestone quarry are located across the LVR north and east of the Site, respectively. Two currently abandoned coal mines are located on the Matthiessen and Hegeler Zinc Company Site. A wetland is located approximately 0.5 mile upstream from the Matthiessen and Hegeler Zinc Company Site, and the Illinois River is located approximately one mile downstream of the Matthiessen and Hegeler Zinc Company Site. The Lake DePue Fish and Wildlife Area and the Spring Lake Heron Colony are located about 15 miles downstream of the Matthiessen and Hegeler Zinc Company Site. The City of LaSalle obtains its drinking water from a cluster of five wells located 0.5 mile south of the southernmost portion of OU1 and 0.89 mile south of the southernmost portion of OU2 (IEPA 2004).

The Matthiessen and Hegeler Zinc Company Site has been divided into OU1 and OU2. OU2 is an US EPA Superfund-lead site where SulTRAC is conducting remedial activities, and OU1 is a PRP-lead site where the PRP consultant, Geosyntec, is conducting remedial activities. SulTRAC is conducting split sampling and oversight of the OU1 RI/FS activities.

The site descriptions of OU1 and OU2 are discussed below.

1.2.1.1 **OU1 Description**

OU1 is comprised of three main areas: 1) the Carus manufacturing facility located on the Plant Area (owned by Carus); 2) a Slag Pile (owned mostly by Carus, with the northernmost approximately 500 ft not owned by Carus, but included in OU1 for the RI) comprised of by-products from the former Matthiessen and Hegeler smelter operations; and 3) the segment of the LVR adjacent to and downstream of the land area of the Site. OU1 (excluding the LVR) occupies about 46.8 acres.

The Plant Area is approximately 17.5 acres and the Slag Pile Area, including the Slag Pile proper and the adjoining area between the Slag Pile and the Plant Area fence and the area south of the Slag Pile and holding pond, is approximately 29.3 acres. Within the LVR, the area where slag is present consists of about 10.5 acres, as measured along the length and width of the river where slag was evident (versus the 17.7-acre upland Slag Pile area). The Carus manufacturing facility is located at 1500 Eighth Street, in the northwest quarter of Section 14 and in the northeast quarter of Section 15 in Township 33 North, Range 1 East of the Third Principal Meridian in LaSalle County, Illinois.

The Slag Pile is located in the northwest quarter of Section 14 in the township referenced above and is bordered to the east by the LVR. The river generally runs from north to south toward its confluence with the Illinois River approximately one mile south of the Site; it also serves as the eastern boundary of OU1 and OU2. The Plant Area of Carus contains five main buildings associated with manufacture of potassium permanganate and other specialty chemicals. Property to the east of the Plant Area includes, from west to east:

- 1) The eastern embankment of Plant Area
- 2) A segment of an abandoned railroad embankment
- 3) An emergency storage pond for Carus facility operations
- 4) The Slag Pile associated with the former operations of the Matthiessen and Hegeler Zinc Company Site

- 5) A holding pond (also known as the south lagoon) which is a currently operating, permitted, National Pollutant Discharge Elimination System (NPDES) facility (Permit Number IL0002623), associated primarily with Carus manufacturing operations

In the Plant Area, surface water is collected and transmitted with non-contact process water to the holding pond through an underground pipe. Surface water from the pond is transmitted through a NPDES permitted point discharge to the LVR. Runoff from the remainder of OU1 flows primarily into the LVR or the holding pond through natural drainage pathways and overland flow.

1.2.1.2 **OU2 Description**

OU2 occupies about 180 acres and is identified as the production area of the former zinc smelting and rolling processes and the immediate property surrounding this area. Specifically, OU2 includes the former Rolling Mill facility, approximately 150 associated former buildings and structures, a shallow slag and sinter pile that heterogeneously covers the former production area of the Matthiessen and Hegeler Zinc Company Site, several abandoned and closed mine shafts, an undeveloped woodland, and surrounding residential areas. Runoff from the shallow sinter and slag pile flows into the LVR through natural drainage pathways and manmade conduits. In the central portion of OU2 west of the abandoned railroad, a conduit runs from an abandoned pump house to the LVR, and an old abandoned and collapsed storm sewer line runs east-west across the entire width of OU2.

1.2.2 **Site History**

The Matthiessen and Hegeler Zinc Company Site began operations in 1858, and various industrial operations have been conducted at OU1 and OU2 through the present day. Industrial operations conducted at OU2 included zinc smelting, rolling of zinc sheets, coal mining, production of sulfuric acid, and production of sulfate fertilizer. Sinter and slag, by-products of zinc smelting, were deposited and in-filled throughout the entire Matthiessen and Hegeler Zinc Company Site. Specifically, during the late 1800s through the early 1900s, slag was deposited on a 17.7-acre, approximately 100-foot-tall upland slag pile now designated as OU1 (along the LVR). The thickness of the deposit ranges upwards to 90 ft. The deposit is located in an area now designated as OU1 (along the LVR). Carus has been operating at OU1 since 1915 and mainly produces potassium permanganate.

The site-specific histories of OU1 and OU2 are discussed below.

1.2.2.1 OU1 History

The manufacturing and business operations of Carus and Matthiessen and Hegeler Zinc Company Site have always been separate. Carus began operations in 1915 in the Plant Area manufacturing potassium permanganate products used for water purification and wastewater treatment. Operations continue through the present time. Carus originally manufactured potassium permanganate at the facility in LaSalle and over time other products were added, including:

- Phosphate corrosion inhibitors
- Manganese dioxide
- Sodium permanganate
- 2, 3 pyridine dicarboxylic acid (PDC)
- Manganese-based catalysts
- Hydroquinone
- Manganese sulfate
- Cesium compounds

A historical overview of the OU1 has been developed based on the following sources: 1) review of available plat surveys of the surrounding area from 1876 to 1925 (obtained from the LaSalle County Historical Society); 2) historical photographs from 1939 to 1988 (obtained from the University of Illinois at Urbana-Champaign); 3) Site topographic maps; and 4) interviews with individuals familiar with historical Site operations.

Historical aerial photographs depicting the Carus and the Matthiessen and Hegeler Zinc Company Site properties from 1939 to 1988 were reviewed. These photographs provide an indication of past disposal practices. In the mid-1800s, Matthiessen and Hegeler Zinc Company Site began placing by-products, including slag and sinter, in the Slag Pile Area within OU1. The property on which the materials were placed was not owned by Carus at that time. In 1876, a large portion of the property now owned by Carus was likely used for agricultural purposes. The LVR flowed from its present location north of the Slag Pile, toward the south-southwest where the holding pond is presently located, and then toward the southeast. By 1939, most of the slag had been placed in its current location. In 1953, a new river channel for the LVR was noted downstream of the Slag Pile, east of the former LVR channel. In 1958, the LVR was more prominent to the east of the Slag Pile, and joined the former river channel downstream of the Site. By 1961, the holding pond had been constructed at the southeast corner of OU1 and received non-contact process water from the Carus manufacturing facility. The holding pond was constructed to

improve handling of non-contact process water and curtail direct discharge into the LVR.

1.2.2.2 OU2 History

Operations at OU2 began in 1858, when raw materials such as zinc ore and various grades of coal were transported to the Site to smelt zinc. A Rolling Mill was built in 1866 to produce zinc sheets. This process included a furnace that used producer gas as fuel, and any sulfur dioxide generated was recovered and converted into sulfuric acid and stored in on-site tanks. OU2 also had an ammonium sulfate fertilizer plant that operated for a few years during the early 1950s. Coal mining occurred on OU2 until 1937, and two mining shafts (one vertical and one horizontal) currently remain. Zinc smelting ceased in 1961, and sulfuric acid manufacturing halted in 1968. From 1968 until 1978, when bankruptcy was declared, the facility performed only Rolling Mill operations. In 1980, Fred and Cynthia Carus purchased the 12-acre Rolling Mill tract of land, which became the LaSalle Rolling Mill.

The LaSalle Rolling Mill worked under contract with the U.S. Mint to generate metal blanks for pennies and operated until 2000, when bankruptcy was declared. In 2003, US EPA conducted an emergency removal action at the LaSalle Rolling Mill to address cyanide contamination, the old plating line, and various other chemicals and storage tanks that remained after the Rolling Mill closure, which is now complete. From 2005 through 2008, Fred Carus leased the former Rolling Mill building and a second adjacent building to the east to a company housing backerboard. As of September 2008, the warehousing business was closed and Fred Carus was attempting to resurrect the operational capacity of several of the zinc sheet rolling machines inside the former Rolling Mill building.

Metals and cyanide were used at OU2 during past operations, including the former zinc smelting process, metal plating, coal mining operations, and generation of residuals and by-products from these processes. The operations included converting raw zinc ore containing zinc sulfide to zinc oxide and subsequent smelting of the zinc oxide sinter to produce metallic zinc. The sulfur from the first phase of the process was recovered and converted into sulfuric acid. Much of the equipment associated with sulfuric acid production was either constructed of lead or was lead-lined. An on-site lead burner was used to manufacture and repair lead components. Other metals were also present in the zinc ore as impurities, including lead and cadmium. A narrow-gauge, on-site industrial railroad was used to move ore about the Matthiessen and Hegeler Zinc Company Site.

Many documented potential organic contaminant sources led to the expectation of potential VOC and SVOC contamination at the OU2 Matthiessen and Hegeler Zinc Company Site. VOC and SVOC usage

have been pervasive, as detailed in the following list of potential VOC and SVOC sources of soil and groundwater contamination on OU2:

- Gasoline-powered locomotives used for moving ore cars around OU2
- Presence of at least one gasoline underground storage tank
- Producer gas used as a fuel source for some of the kilns
- Machinery and engine oils used throughout OU2
- Coal burning
- Presence of carbon tetrachloride fire extinguishers
- Presence of research (analytical) laboratories
- Presence of engine/machine shops

During at least part of the time that the Matthiessen and Hegeler Zinc Company Site was in operation, the Site generated its own electrical power for use in the OU2 zinc refining plant and coal mine. Several transformers are known to have been located on OU2, and the removal of the transformers was not documented. PCBs were commonly used in electrical transformers manufactured between 1929 and 1977. Additional potential sources of PCBs include lubricating and hydraulic oils that may have been used in on-site equipment.

It was a common practice in the mid-1900s to spray herbicides to control vegetation near railroads, three of which were located on the Matthiessen and Hegeler Zinc Company Site, mainly on OU2: the Illinois Central Railroad (ICRR) on the east, the LaSalle and Bureau County Railroad on the west, and an on-site narrow-gauge industrial railroad. Pesticides may have also been used during Site operations.

Asbestos was used as a building material (transite walls and roofs), as thermal insulation, and for fire proofing in many of the 150 OU2 buildings. In addition, steam pipes that traversed OU2 were wrapped in asbestos-type insulation.

1.2.3 Previous Investigations

The Matthiessen and Hegeler Zinc Company Site was listed on the NPL on September 29, 2003 (US EPA 2003d). Two primary on-site sources were used to score the Matthiessen and Hegeler Zinc Company Site for the NPL. The first source is the 17.7-acre upland slag and sinter pile mostly located on OU1. The PRPs are addressing this contamination source, and SulTRAC is providing technical oversight assistance to the US EPA for PRP-lead activities. The second source, located at OU2, is a shallow waste pile of

sinter and slag heterogeneously deposited throughout the former smelter property. US EPA is addressing this contamination source, and SulTRAC is providing technical assistance to the US EPA.

Previous investigations at OU1 and OU2 are discussed below.

1.2.3.1 OU1 Investigations

The contaminant source at OU1 is the slag and sinter pile located on OU1. As the slag and sinter are by-products of former zinc smelter operations, the contaminants in the slag and sinter are a result of former zinc smelter activities. Runoff from this slag and sinter waste pile flows into the LVR through natural drainage pathways. Previous investigations have been conducted on OU1 by the IEPA and Geosyntec within the Carus Plant Area, the Slag Pile Area, and the LVR.

IEPA performed a preliminary assessment and screening site inspection (SSI) of the Carus Plant Area in 1991. Four surface soil samples, one background surface soil sample, eight sediment samples, three groundwater samples, and one background groundwater sample were collected. Samples collected during the IEPA SSI were submitted for laboratory analysis for the suite of organic and inorganic chemical constituents contained on the US EPA Target Compound List (TCL) and Target Analyte List (TAL). Soil results indicate that arsenic, lead, and manganese were greater than the industrial soil Preliminary Remediation Goal (PRG) in one or more soil samples. Groundwater results indicate that aluminum, arsenic, cadmium, chromium, iron, lead (screened against the MCL), manganese, vanadium, and zinc were detected at concentrations in excess of US EPA PRGs for tap water. Sediment results indicate that cadmium, copper, cyanide, lead, mercury, nickel, and zinc were detected at concentrations exceeding ecological screening criteria in one or more of the river sediment samples.

Geosyntec conducted a Preliminary Site Investigation (PSI) at the Carus Plant Area in 1992. The scope of work included:

- 1) Advancement of 16 soil borings and collection of soil samples for laboratory analysis
- 2) Installation of two groundwater monitoring wells (MW)
- 3) Collection and laboratory analysis of soil and sediment samples from the LVR and the holding pond
- 4) Collection of five unfiltered groundwater samples from the two newly installed MWs and three existing wells (those sampled during the IEPA SSI in November 1991)
- 5) Measurement of water levels in MWs to evaluate groundwater flow

- 6) Performance of a single well aquifer test (slug test) in a MW located within the Slag Pile east of the railroad embankment

Soil samples collected during the Geosyntec PSI were extracted using US EPA Method 1311, the Toxicity Characteristic Leaching Procedure (TCLP) and were analyzed for the eight Resource Conservation and Recovery Act (RCRA) metals which included:

- Arsenic
- Barium
- Cadmium
- Chromium
- Lead
- Mercury
- Selenium
- Silver

The groundwater quality results for the two MW samples indicated that arsenic and lead were detected at concentrations in excess of the US EPA PRG and MCL, respectively, for tap water in five groundwater samples. Chromium and cadmium were detected at concentrations in excess of the US EPA PRG for tap water in G103 and G106, respectively. The analytical results for sediment samples collected in the river during the PSI indicate that seven metals were detected. No inorganic constituents were detected at concentrations exceeding the ecological screening criteria in river sediment samples. The TCLP data indicate that most of these metals were either not detected or were detected at concentrations well below the US EPA TCLP criteria. Two samples, however, did indicate TCLP concentrations in excess of the regulatory limits. These include: sample B3/S1, collected from an area where sinter had been deposited, which indicated a cadmium concentration of 1.15 milligram per liter (mg/L), which slightly exceeds the US EPA TCLP limit of 1 mg/L for cadmium; and sample GW2/S1, collected from the slag deposit area, which indicated a concentration of lead of 5.21 mg/L, which slightly exceeds the TCLP limit of 5 mg/L for lead.

Geosyntec conducted an investigation in November 1993 at the Carus Plant Area and the findings were presented in a report which was submitted to the IEPA in January 1994. The scope of work conducted as part of the November 1993 investigation included:

- 1) Advancement of 18 soil borings
- 2) Completion of three of the soil borings as groundwater MWs
- 3) Performance of a water supply well exposure survey
- 4) Evaluation of existing groundwater MWs
- 5) Slug testing
- 6) Water level measurements

- 7) Soil sampling and analysis
- 8) Surface-water sampling and analysis
- 9) Groundwater sampling and analysis

Based on the results of the water supply well exposure survey, Geosyntec concluded that there is little potential for human exposure to groundwater through private wells. The laboratory results for soil samples collected during the investigation revealed elevated concentrations of inorganic constituents at some sample locations, primarily for samples collected from areas containing slag, sinter, and other industrial by-products associated with past Matthiessen and Hegeler Zinc Company Site operations. Two metals, arsenic and lead, exceeded their respective PRGs in some sampling locations. Samples collected from fill materials containing slag indicated elevated concentrations of cadmium, lead, zinc, and sulfate compared to concentrations detected in native geologic materials. Groundwater results indicated that eight inorganic constituents (arsenic, cadmium, copper, iron, lead, manganese, vanadium, and zinc), naphthalene, and benzene, toluene, ethylbenzene, and xylene (BTEX) constituents were detected at concentrations exceeding screening criteria. The water quality data suggested that groundwater impacts from sulfate were present in the Plant Area.

Geosyntec conducted an investigation in 1994 focused on the portion of the Slag Pile present on land owned by Carus, and the findings were presented in a report which was submitted to the IEPA in January 1996. The scope of work included:

- 1) A site inspection
- 2) Evaluation of the holding pond
- 3) Meteorological assessments
- 4) Surface-water sampling in the LVR and analysis
- 5) Sediment sampling in the LVR and analysis
- 6) Advancement of 18 soil borings, and soil sampling and analysis, principally in the Slag Pile
- 7) Installation of 10 piezometers
- 8) Water-level measurements
- 9) Slug and pump tests
- 10) Groundwater sampling and analysis

The soil (principally slag material) analytical results for total lead were in excess of the Industrial PRG SV. Additionally, chromium, iron, and manganese were detected at concentrations greater than corresponding screening criteria in one soil sampling location each. Groundwater results indicated that cadmium, iron, lead, manganese, nickel, zinc, benzene, and xylenes were present at concentrations in

excess of screening criteria. The highest concentrations of cadmium (2.22 mg/L) and zinc (831 mg/L) were detected in Piezometer P-1, which had a pH of 4.3. The river sediment results indicate concentrations of cadmium, lead, mercury, nickel, and zinc at concentrations in excess of at least one of the ecological screening criteria; however, no TCLP criteria were exceeded. Several constituents were detected at concentrations in excess of ecological screening criteria, including iron, lead, mercury, zinc, and cyanide, in the surface-water samples collected from the LVR.

1.2.3.2 OU2 Investigations

IEPA conducted a CERCLA preliminary assessment in 1993 and a CERCLA integrated assessment in 1994 of the contaminant sources at the Matthiessen and Hegeler Zinc Company Site (IEPA 1993a, 1994). The results are summarized in this section.

The primary contaminant source at OU2 is a shallow waste pile of sinter and slag heterogeneously deposited throughout the former smelter property. Contaminants discovered in this source appear to have resulted from former zinc smelter activities and ancillary operations as described in [Section 1.2.2.2](#). Runoff from this shallow sinter and slag waste pile flows into the LVR through natural drainage pathways and manmade conduits. For example, in the central portion of OU2 west of the abandoned railroad, a conduit runs from an abandoned pump house north to the LVR, and an old abandoned storm sewer line runs east-west across the entire width of OU2.

IEPA conducted a CERCLA preliminary assessment in 1993 and a CERCLA integrated assessment in 1994 of the contaminant sources at the Matthiessen and Hegeler Zinc Company Site (IEPA 1993a, 1994). Nine soil samples were collected from seven locations throughout OU2. Two of the seven locations were sediment sampling locations along the western bank of the LVR. These samples were collected to evaluate whether an observed release to surface water from OU2 had reached the LVR. The hazardous substances detected in the nine samples included pentachlorophenol (maximum concentration of 36 milligram per kilogram [mg/kg]), cadmium (maximum concentration of 1,320 mg/kg), copper (maximum concentration of 3,650 mg/kg), lead (maximum concentration of 4,310 mg/kg), and zinc (maximum concentration of 71,200 mg/kg) (US EPA 2008b). The sediment samples collected along the bank of the LVR contained elevated levels of arsenic, cadmium, chromium, lead, nickel, and zinc confirming that OU2 was the source of a surface water release to the LVR (IEPA 1994).

During the 1994 CERCLA integrated assessment, several soil samples collected from nearby residential properties contained elevated levels of metals, primarily arsenic, cadmium, chromium, lead, and zinc,

associated with the Matthiessen and Hegeler Zinc Company Site (IEPA 1994). The presence of cadmium, lead, and arsenic in the residential soil samples spurred the Agency for Toxic Substances and Disease Registry (ATSDR) and the Illinois Department of Public Health (IDPH) to issue a public health statement in September 1999 calling the Matthiessen and Hegeler Zinc Company Site a public health hazard as confirmed by laboratory results (IDPH 1999). Trespassers may be exposed to the contamination and can easily access OU2 through large holes in the fence or in the LVR.

On September 3, 2003, the US EPA and Mr. Fred Carus, on behalf of the LaSalle Rolling Mill (LRM), entered into an Administrative Order on Consent (AOC) (US EPA 2003c). The AOC required the LRM to address eight Areas of Concern, regarding storage tanks, plating lines, residual product and waste material, and asbestos. During the site inspection in 2000, the US EPA established that the waste storage practices and site conditions at the LRM posed a threat to human health and the environment. During the removal actions the following actions were completed (Dykton 2008):

- Area of Concern 1: 19,407 gallons of liquid were removed from the secondary contaminant structure and discharged into the LaSalle sanitary sewer
- Area of Concern 2: The entire plating line, including all associated equipment, appurtenances, and chemical wastes were removed and disposed of off-site
- Area of Concern 3: Three chemical treatment tanks were emptied (9,939 gallons) and disposed of off-site
- Area of Concern 4: Residual chemicals and products in the LRM's facility process laboratory and abandoned drums from across the facility were removed and disposed of off-site
- Area of Concern 5: Bulk oils were removed from storage tanks and secondary contaminant structures and disposed of off-site
- Area of Concern 6: Three areas of unpermitted storage of containerized waste were removed and disposed of off-site
- Area of Concern 7: Oil-contaminated soil piles were excavated at least to grade and disposed of off-site
- Area of Concern 8: Asbestos abatement activities were completed during October 2004

On June 11, 2008, the LRM completed the removal actions and submitted their Final Report on June 23, 2008 for their activities at the Site (US EPA 2009a).

In 2008, the US EPA tasked their Superfund Technical Assessment and Response Team (START) contractor (STN Environmental) to conduct a removal assessment of the Matthiessen and Hegeler Zinc Site. START completed the following work in the removal assessment (STN 2008):

- 1) Prepared a health and safety plan and sampling plan
- 2) Investigated unknown chemicals in a former chemical laboratory
- 3) Conducted potential asbestos containing material sampling outside the Rolling Mill, former chemical laboratory, and Building 1943
- 4) Investigated unknown oil in sewer drains associated with the Rolling Mill
- 5) Documented on-site conditions with written logbook notes and photographs
- 6) Procured analytical services
- 7) Performed analytical data validation
- 8) Prepared a Removal Assessment Report

The assessment found friable asbestos outside the Rolling Mill, former chemical laboratory, and Building 1943. Additionally, materials were sampled with measured concentrations of arsenic, cadmium, lead, and zinc in excess of the US EPA Regional Screening Level (RSL), Soil Screening Level (SSL), and TCLP criteria. The assessment report concluded the following: “the presence of toxicity characteristic hazardous wastes in exceedance of regulatory criteria, friable asbestos, and deteriorating conditions where hazardous wastes are stored at the Site, posed actual and potential threats to human health and the environment and meets the criteria for an US EPA removal action as listed in 40 Code of Federal Regulations (CFR) §300.415 (b)(2)” (STN 2008).

In 2009, the US EPA tasked their START contractor (Weston Solutions, Inc. [Weston]) to conduct removal activities as outlined by the 2008 removal action assessment (STN 2008) at the Matthiessen and Hegeler Zinc Company Site. Removal activities took place from September 8 through 12, 2009 and consisted of: (1) the removal of asbestos containing material from the former chemical laboratory building, outside the Rolling Mill, and north of Building 1943; and (2) demolition of the former chemical laboratory building. Approximately 48 linear ft of asbestos pipe wrap was abated. A total of 209 tons of construction debris, 8.86 tons of construction debris with friable asbestos, and 85.91 tons of soil with friable asbestos were removed and disposed of off-site. Daily perimeter air sampling was conducted during the asbestos abatement and demolition. All daily perimeter air sampling results were below laboratory detection limits or less than the exposure limits, except for one sample. Based on the removal activities performed, the laboratory building and asbestos abated during the removal action no longer

posed an imminent or substantial threat to human health, human welfare, or the environment (Weston 2009).

The US EPA reported the Rolling Mill to the Occupational Safety and Health Administration (OSHA) for “employees working in the warehouse are exposed to friable asbestos”. OSHA issued a citation on October 29, 2009 for an unpermitted operator inside the Rolling Mill (OSHA 2009).

1.3 REPORT ORGANIZATION

This report consists of the 10 sections summarized below. All tables and figures referred to within a section are located at the end of that section.

- [Section 1.0, Introduction](#): This section discusses the purpose of the report, the Site background, and the report organization.
- [Section 2.0, RI Activities](#): This section discusses RI activities conducted at the Site.
- [Section 3.0, Physical Characteristics of the Site](#): This section discusses the Matthiessen and Hegeler Zinc Company Site general setting and site-specific features.
- [Section 4.0, Nature and Extent of Contamination](#): This section discusses sources of contamination and analytical results for all matrices sampled at the Matthiessen and Hegeler Zinc Company Site.
- [Section 5.0, Contaminant Fate and Transport](#): This section discusses physiochemical factors affecting chemical fate and transport, chemical persistence, expected chemical fate and transport, and potential contaminant migration routes for the Matthiessen and Hegeler Zinc Company Site.
- [Section 6.0, Conceptual Site Model](#): This section presents the conceptual site model (CSM) for OU1, OU2, and the entire Matthiessen and Hegeler Zinc Company Site.
- [Section 7.0, Human Health Risk Assessment](#): This section discusses the HHRA for OU1, OU2, and the entire Matthiessen and Hegeler Zinc Company Site.
- [Section 8.0, Ecological Risk Assessment](#): This section discusses the ERA for OU1, OU2, and the entire Matthiessen and Hegeler Zinc Company Site.
- [Section 9.0, Summary and Conclusions](#): This section summarizes Sections 4.0, 5.0, 6.0, 7.0, and 8.0, and then provides conclusions drawn based on RI findings and recommendations for additional work at the Matthiessen and Hegeler Zinc Company Site.
- [Section 10.0, References](#): This section lists all references used to prepare this RI report.

2.0 RI ACTIVITIES

US EPA and the PRPs currently are addressing the contamination at the Matthiessen and Hegeler Zinc Company Site through an RI/FS that includes two OUs: OU1 and OU2. OU1 is a PRP-lead site where the PRP, Carus, is conducting the RI. OU2 is an US EPA Fund-lead site where SulTRAC is conducting the RI. The long-term cleanup of the Matthiessen and Hegeler Zinc Company Site is being addressed under US EPA's Superfund Division's remedial process.

As described in [Section 1.0](#) of this RI report, Carus agreed to perform the RI/FS on the portion of the Matthiessen and Hegeler Zinc Company Site that it currently owns (OU1) as well as on the LVR. Geosyntec is providing PRP technical support for OU1 activities, and SulTRAC is providing oversight and split sampling on behalf of the US EPA. US EPA conducted the RI/FS on the remainder of the Matthiessen and Hegeler Zinc Company Site and in adjacent residential areas, with SulTRAC providing technical support.

The following sections discuss investigation activities at OU1 ([Section 2.1](#)), OU2 ([Section 2.2](#)), and site-wide ([Section 2.3](#)).

2.1 OU1 INVESTIGATION ACTIVITIES

The scope of the RI/FS activities at OU1 was developed with US EPA based on historic site investigation data and an understanding of historic and current site operations.

Based on available Site information, Geosyntec proposed and the US EPA concurred that OU1 RI activities be divided into a minimum of two phases. Phase I focused on characterization of the nature and extent of contamination at OU1. The Phase II investigation focused on further characterization of the LVR and the Slag Pile / LVR interaction. Additional investigation was also performed to evaluate groundwater/surface water interaction and potential discharge of groundwater to the LVR. The RI activities on OU1 were conducted in accordance with the US EPA-approved Work Plan dated July 2007 (Geosyntec 2007a), Work Plan Addendum No. 1 and Field Sampling Plan (FSP) Addendum No. 1, both dated April 2009 (Geosyntec 2009b), and the Sediment Toxicity Testing Work Plan dated April 2011 (Geosyntec 2011a).

The Phase I field activities included:

- 1) Advancing soil borings at 18 locations to characterize the area lithology, and the vertical extent of the Slag Pile
- 2) Collecting solid matrix samples from soil borings at eight locations in the Plant Area and ten locations in the Slag Pile Area
- 3) Excavating 31 trenches to evaluate the lateral boundaries of the Slag Pile Area
- 4) Evaluating and redeveloping the previously existing MW network
- 5) Installing 14 MWs to supplement the existing well network, collecting 15 groundwater samples
- 6) Characterizing the Site hydrogeology
- 7) Collecting eight surface water samples and 15 sediment samples at locations within the LVR
- 8) Collecting 20 sediment grab samples at sediment depositional areas
- 9) Installing three staff gauges in the LVR

During Phase I, Geosyntec also conducted ERAs, including the investigation of habitat types, possible pollutant transport routes, and possible indicator species.

The Phase II field activities included:

- 1) Installing and sampling two temporary MWs at the Slag Pile/ LVR interface
- 2) Collecting 19 sediment samples and 27 surface water samples for conventional analytical testing
- 3) Collecting nine slag and sediment samples and 25 liters of river water for specialized leachability testing

A biological assessment of the LVR was comprised of three main scopes of work:

- 1) A fish and macroinvertebrate community assessment to evaluate the biological health of the river
- 2) Calculation of an index of biotic integrity
- 3) Analysis of biological tissue

The OU1 soil/solid matrix, groundwater, surface water, and ERA are discussed below.

2.1.1 Soil Investigation

The OU1 soil investigation is referred to as the Solid Matrix Characterization Program as it includes both waste material (e.g., sinter and slag) and natural soil. The program addressed two major sampling areas:

- 1) the Slag Pile Area; and 2) the Carus Plant Area.

The Phase I and II soil investigations at OU1 are discussed below. Figures 2.1.1-1 and 2.1.1-2 show soil sampling locations at the Plant Area and the Slag Pile Area, respectively. Table 2.1.1-1 summarizes information for the OU1 Phases I and II samples collected.

2.1.1.1 Phase I Soil Investigation

As part of the Solid Matrix Characterization Program, during October 2007, soil borings were drilled using sonic drilling technology at 18 locations to characterize the area lithology and the vertical extent of the Slag Pile. Solid matrix samples were collected from soil borings at eight locations in the Plant Area and ten locations in the Slag Pile Area.

Soil borings at the Plant Area were advanced to a maximum depth of 4-ft below ground surface (bgs). Samples from each 2-ft interval were field-screened for organic vapors with a hand-held photoionization detector (PID). Samples were selected for laboratory analysis from the following criteria:

- A sample collected from the 0 to 1-ft bgs interval or, if concrete/pavement was present, the first 0 to 1-ft below the concrete/pavement
- A sample collected from 2 to 4-ft bgs, unless PID readings above background were observed, in which case the second sample was targeted to a 2-ft interval centered on the horizon with the highest PID readings

In the Slag Pile Area of OU1, solid matrix samples were generally collected at intervals of 0 to 1-ft bgs, 5-ft above the water table, and 5-ft below the water table for samples in the Slag Pile Area. Exceptions to this general rule were as follows:

- If the slag terminated before 5-ft below the water table, the third sample was collected in the saturated zone 1-ft above the bottom of the slag
- If the bottom of slag was observed above the water table, then the second sample was collected 1 ft above the bottom of slag or 5-ft above the water table (whichever was higher), and the third sample was collected in alluvium at least 1-ft below the bottom of slag and up to 5-ft above the water table

All solid matrix samples were analyzed for TAL metals as they are the most prevalent chemicals present in soils and slag based on previous investigations conducted in the OU1 area. A subset of samples was analyzed for VOCs, SVOCs, pesticides, PCBs, and cyanide, as these chemicals have been measured in Site media to a more limited extent than the metals. The relative percent of the subset analyzed is

consistent with the relative observations measured in Site media during earlier investigations at OU1. The samples designated for VOCs, SVOCs, PCBs, cyanide, and pesticides were selected on a rotational and sequential basis to ensure a randomly spatial sampling design (no bias as to sampling depth or location). Geochemical parameters were collected to evaluate fate and transport mechanisms and bioavailability in the soil and slag.

A field geologist logged all soil borings using lithology logging forms. Boring logs for OU1 borings are presented in Appendix G-2-1. For each soil boring location, the following information was included on the logging form: site name, project name, boring number, drilling method, boring diameter, depth to water, date started, date completed, geologist's initials, drilling subcontractor name, and information adequate to find the boring location if warranted. During boring advancement, the following information was also recorded on the geologic logging form: lithologic description, time each interval was collected, depth, drive interval, recovered interval, and organic vapor measurement collected using a PID. The lithologic description recorded for each interval included color, texture, and lithology. If slag, sinter, soil, or debris piles were encountered, this information was recorded. Soil boring sample identifications were entered for the appropriate depth interval in the log. Soil boring intervals were photographed with a tape measure for scale, and the sample identification and depth were written on a whiteboard. Photographs have been archived.

The slag characterization program also addressed delineation of Slag Pile Area depths, thicknesses, and volume related to OU1, as well as the elevations of the underlying natural soil layer and the extent of cover (if present) over the slag. Soil borings SB-301, SB-303, and SB-305 were advanced through the slag and underlying alluvium to the top of bedrock, while other borings (SB-302, SB-304, SB-306, SB-308, SB-309, SB-320, SB-321, and SB-322) penetrated into or through the slag without encountering bedrock. During September through December 2007, test trenching was conducted with a backhoe to delineate the southern, northern, and western edges of the Slag Pile. Thirty-one trenches were excavated to evaluate the lateral boundaries of the Slag Pile Area (Figure 2.1.1-2). Aerial photographs of the Site were also reviewed to understand historical slag placement.

Personal and area real-time air monitoring/sampling were conducted in accordance with the Health and Safety Plan. Level C personal protective equipment (PPE) was implemented for trenching activities. PPE was downgraded to Level D for all field activities after receipt of favorable air monitoring results early in the trenching task. During soil boring activities, air monitoring was conducted by inserting the PID probe into the headspace of plastic bags that encased the soil boring samples and the results were recorded.

2.1.1.2 Phase II Soil Investigation

Slag samples were collected from two sources of slag, the Slag Pile and the LVR, and evaluated for leachability using three different tests: 1) a specialized leachability test; 2) conventional Synthetic Precipitation Leaching Procedure (SPLP) on both sieved and unsieved samples; and 3) Sequential Extraction Procedure (SEP) testing. Slag samples were collected from three locations within each source of slag. The purpose of the slag leachability tests was to better understand the potential for leaching of metals from the slag into the river, as well as the potential for “weathering” of slag after protracted exposure to river water.

The three Slag Pile sampling locations (SLP-415, SLP-416, and SLP-417), are shown in Figure 2.1.1-2. The samples from the Slag Pile were collected from the steepest angle of repose in the following locations: 1) near the northern extent of the Slag Pile (SLP-417); 2) 500-ft south of the northern extent (SLP-416); and 3) 1,000-ft south of the northern extent of the Slag Pile (SLP-415). Soil sieves were used to process one sample from each location, resulting in a sample that contained material that passed a 1-inch sieve, but was retained on a 0.187 inch sieve. Native materials were manually separated from slag materials.

The LVR slag sampling locations (LRS-412, LRS-413, and LRS-414), are shown in Figure 2.1.1-3. The samples collected from the LVR were located in the general vicinity as the sediment samples collected from depositional areas at the following locations: adjacent to the Slag Pile, south of the 5th Street Bridge, and north of the concrete plant to better assess how the slag leachability may vary with location in the river. Soil sieves were used to process one sample from each location, resulting in a sample that contained material that passes a 1-inch sieve, but retained on a 0.187 inch sieve. Native materials were manually separated from slag materials.

Three slag samples were collected, sieved, and sorted as described above for additional testing, including conventional SPLP and SEP testing. These samples included one sample collected from the Slag Pile (SLP-415) and two collected from the LVR (LRS-412 and LRS-413). The sieved slag samples subjected to conventional SPLP and the SEP testing were analyzed for the 23 TAL metals. In addition, from each of these three locations, an unsieved sample was collected for conventional SPLP testing and analyzed for the 23 TAL metals.

2.1.2 Groundwater Investigation

In general terms, the goals of the groundwater characterization program are summarized as follows:

- Perform sufficient groundwater characterization in the two most significant transport media, slag and alluvium
- Develop a sufficient understanding of bedrock groundwater conditions
- Conduct a limited characterization of other media, including fill and Pleistocene till
- Evaluate vertical gradients among media
- Perform an analytical sampling program that addresses analytical parameters while focusing on those of greatest significance (i.e., metals)
- Collect groundwater samples of consistent quality to avoid unnecessary variability in sample turbidity or well productivity
- Incorporate groundwater quality data generated in OU1
- Perform representative hydraulic characterization of sampling media

Two phases of field activities, described below, were implemented to meet goals of the Groundwater Characterization Program.

2.1.2.1 Phase I Groundwater Investigation

Prior to the initiation of the RI scope of work, a MW network, consisting of 18 MWs screened in bedrock, alluvium, and slag, existed with the OU1 area. A reconnaissance of the existing well network was conducted in September 2007 to evaluate the competency of the wells for future sampling. Five years had passed since the wells were last developed, and some were in a state of disrepair. The wells were redeveloped and the turbidity closely monitored. The integrity of the well cap, pad, and locking mechanism were also evaluated.

During September through December 2007, 14 MWs were added to the OU1 MW network to supplement the existing well network. All 14 MWs had 10-ft long screened intervals completed at various depths. Two new MWs were screened in bedrock. Six new MWs were screened in alluvium (Holocene) and six new MWs were screened in the slag. Figure 2.1.2-1 shows the OU1 MW network. Boring logs for all borings and MWs are presented in Appendix G-2-1.

MW installation was performed using sonic drilling technology. Samples were collected continuously from 10-ft intervals for lithologic logging purposes. A field geologist logged all borings and the following information was recorded on the geologic logging form: time each interval was sampled, depth, drive interval, recovered interval, and organic vapor measurement. The lithologic description also was recorded for each interval, including color, texture, and lithology. If slag, sinter, soil, or debris was

encountered, these materials were specifically identified on the logging form and in the respective field notebook. MW boring intervals were photographed, and the photographs have been archived. Table 2.1.2-1 provides MW construction details. Well construction logs for all wells and piezometers installed on OU1 are presented in Appendix G-2-2.

The MWs were constructed of 2-inch diameter polyvinyl chloride (PVC) with 10-ft long screens with a 0.010-inch slot size. A clean filter pack was installed from the surface by pouring coarsely graded sand through a tremie pipe to the interval from 1 ft below to 1 ft above the well screen. The sand was poured slowly, and the level of the sand was periodically tested with a weighted steel tape to ensure that no bridging was occurring. A 2-ft thick seal of bentonite pellets was installed at the top of the filter pack, and the annular space from the top of the bentonite seal to the surface was filled with bentonite chips. Surface completion consisted of installing a concrete pad with a 4-inch diameter steel outer protective casing that rises approximately 2 ft above grade. Wells were completed with expandable locking caps and three concrete bollards surrounding each well location. After well installation, a licensed surveyor surveyed the ground surface elevation, top of casing elevation, and horizontal location of all new wells.

For each MW, a Geosyntec geologist recorded well construction details on-site on Geosyntec MW completion forms. After installation, all MWs were developed prior to the first round of sampling. Development consisted of surging the well to remove fine sediments, followed by pumping to remove approximately five well volumes of water from each well. Wells were considered developed when turbidity, dissolved oxygen (DO), pH, temperature, and conductivity stabilized to within 10 percent over three consecutive measurements taken at 5-minute intervals or if a minimum of five well volumes were removed and the water was visibly clear of suspended solids. These conditions typically indicate formation water from the water-bearing unit.

Groundwater samples were collected from 15 MWs (Figure 2.1.2-1) during the months of December 2007 and January 2008 (several of the wells were dry or were not adequately productive to provide sufficient groundwater for sampling). Field parameters were considered stabilized after three successive measurements taken at a minimum of 3-minute intervals were within the following ranges: ± 0.1 standard unit for pH, ± 0.5 °C for temperature, ± 3 percent for conductivity, ± 10 millivolts (mV) for oxidation-reduction potential, and ± 10 percent for turbidity and DO. If the parameter stabilization ranges could not be met, samples were collected after three well volumes were purged. All groundwater parameters were measured using a YSI 556 MPS with a flow-through cell and a LaMotte 2020 turbidity meter. Available well development records are included in Appendix G-2-4.

The analytical program (Table 2.1.1-1) for groundwater included the following analyses in the proportions given: 1) TAL metals in all samples; 2) VOCs, SVOCs, and cyanide in 25 percent of samples; 3) field parameters (including ferrous iron, sulfide, and alkalinity) in all samples; and 4) total organic carbon (TOC), orthophosphate, and sulfate in selected locations.

All samples were immediately placed in an iced cooler until they were delivered to the laboratory under standard chain-of-custody protocol. Concurrent rounds of site-wide water levels were collected periodically. All water levels were collected on the same day. To further supplement the hydraulic characterization of OU1, a slug test was conducted on January 17, 2008 at MW G-106.

2.1.2.2 Phase II Groundwater Investigation

Two temporary MWs, ISW-001 and ISW-002, were installed June 16-18, 2009, in the shallow subsurface to obtain samples of interstitial water. These temporary MW locations are shown in Figure 2.1.2-1. The temporary MWs were located near the interface of the Slag Pile and the LVR to assess the concentrations of metals within the pore water, and also to measure the water table at this interface in order to evaluate potential contributions from groundwater to surface water in the LVR. A third temporary MW was attempted; however, difficult drilling conditions did not allow for installation of a third well. Water levels were measured in these wells and in the adjacent LVR in June after installation, and again in August and October 2009. The wells were sampled June 19 and again on August 19, 2009. The LVR was not sampled at the time the wells were sampled. Data on the water level measurements are in Appendix G-2-3.

Field personnel advanced the boreholes to depths of 4.5-ft (ISW-001) and 10-ft bgs (ISW-002). Pre-pack wells screens were utilized to build the temporary wells. The well screens were 2.5-ft in length with a two-inch inside diameter casing. Schedule 40 PVC riser pipe was used and extended approximately 2.5-ft above ground. The pre-pack well was placed vertical in the hole and the annular space filled with natural material. To the extent practical given subsurface conditions, well screens were fully submerged below the water table. The top of casing and the ground surface of each temporary well were surveyed for horizontal and vertical control by a State of Illinois registered land surveyor. Horizontal control is based on Illinois State Plane - East, North American Datum (NAD) of 1983. Elevation measurements are based on National Geodetic Vertical Datum (NGVD) of 1929. Elevations of the interstitial water in each well and the river adjacent to each temporary well were collected to establish flow conditions. Temporary MWs were developed prior to sampling using a peristaltic pump. Purge water collected during well development was containerized and disposed of as described in Section 5 of the original FSP (May 2007).

Interstitial water samples were collected from the two temporary MWs during June 2009 and again during August 2009. Field parameters were considered stabilized after three successive measurements taken at a minimum of 3-minute intervals were within the following ranges: ± 0.1 standard unit for pH, ± 0.5 °C for temperature, ± 3 percent for conductivity, ± 10 mV for oxidation-reduction potential, and ± 10 percent for turbidity and DO. All interstitial water parameters were measured using a YSI 556 MPS with a flow-through cell and a Hanna HI 98703 turbidimeter. Appendix G-2-4 includes the well development records and summarizes all sampled MWs and their stabilization parameters.

The analytical program (Table 2.1.3-1) for interstitial water included the following analyses: 1) TAL metals in all samples; and 2) hardness in all samples.

Both total (unfiltered) and dissolved (filtered) surface water and interstitial water samples were collected and analyzed. Dissolved samples were filtered in the field. All samples were immediately placed in an iced cooler until they were delivered to the laboratory under standard chain-of-custody protocol.

2.1.3 Surface Water and Sediment Investigation

The surface water and sediment investigation was included in the Surface Water and Sediment Characterization Program which addressed three areas of the Site: 1) the LVR; 2) the upland area of OU1; and 3) the ASO and the active Combined Sewer Overflow (CSO) outfall in OU2. The Surface Water and Sediment Characterization Program was conducted using a phased approach. The first phase, completed as part of the initial field effort, consisted of two primary components: 1) physical characterization; and 2) analytical evaluation of sediments and surface water. Based on the first phase of work, additional sediment and surface water samples were collected during Phase II of the RI. Phase II consisted of two primary components: 1) analytical evaluation of sediments and surface water, including at the ASO and CSO; and 2) specialized leachability testing of the slag (weathered and unweathered).

2.1.3.1 Phase I Surface Water and Sediment Investigation

The objective of the physical characterization aspect of the program was to collect information to allow mapping of the LVR with respect to slag deposition. In October 2007, the LVR was traversed by foot from the Illinois River to the Quarry Bridge (approximately 13,000-ft in length). Visual observations of slag depositional areas and slag boulders (greater than one-ft) were noted along the river length of inquiry. To quantify the slag mass fraction of LVR sediment, 12 grab samples were collected at sediment deposition locations (LVR-200 series sample numbers). Sample collection locations are shown in Figure

2.1.3-1. This figure also shows locations sampled by IEPA in 1991 and 1994, and the Phase II sampling locations, LVR- and LRS-400 series sample numbers).

The objective of the analytical program was to collect sediment and surface-water samples to evaluate potential impacts associated with the Slag Pile to the LVR. Eight surface water samples and 12 sediment samples were collected at locations within the LVR. Sample collection locations are shown in Figure 2.1.3-1 (sediment samples) and Figure 2.1.3-2 (surface water samples). Samples were collected upstream of the Site, adjacent to the Site, and just downgradient of the Site, based on sediment depositional areas.

The analytical program (Table 2.1.3-1) consisted of the following:

- 1) TAL metals in all samples
- 2) VOCs, SVOCs, PCBs, and pesticides and cyanide in 25 percent of samples along the Site proper and in both upstream locations
- 3) Pesticide characterization in all locations near the group of historical pesticide exceedances (LVR-206, LVR -207, and LVR -208)
- 4) Acid Volatile Sulfides/Simultaneously Extracted Metals (AVS/SEM) analysis in four locations along the Site proper

At the time of surface water sample collections, field measurements of temperature, conductivity, DO, turbidity, pH, and oxidation reduction potential (ORP) were recorded using a YSI 556 MPS with a flow-through cell and a LaMotte 2020 turbidimeter. Surface water samples were collected using a decontaminated glass measuring cup.

Samples for VOC analyses were collected first and placed directly into the appropriate sample containers leaving no headspace, followed by sample collection for metals, SVOC, PCB, and pesticides analyses. All samples were immediately placed in an iced cooler until they were delivered to the laboratory under standard chain-of-custody protocol.

Sediments samples were collected using stainless steel spoons and bowls. Sieves were used to separate large grained material and large pieces of natural, organic material. All samples were immediately placed in an iced cooler until they were delivered to the laboratory under standard chain-of-custody.

Three staff gauges were installed and surveyed in the bank of the river during the 2007 field season at roughly equidistant locations along the length of OU1 to allow a comparison of river stage values with potentiometric data from MWs. The integrity of the staff gauges were compromised due to high flows

and debris in the river. Subsequently, three river stage measuring points were installed and surveyed along the length of OU1 during Phase 2 of the RI field effort using a more durable design. Those locations were revisited and a fourth location established during the June 2009 sampling event to confirm they were still in place. River levels were measured during June, August, and October 2009; these data are summarized in Table 2.1.3-2. Those locations will be used in the future to establish the river stage relative to the well water levels. The River Gauge locations are shown on Figure 2.1.3-2.

The upland characterization program was also conducted during Phase I. Potential surface water accumulation pathways were predicted based on computer-generated flow maps using Site topography. OU1 was traversed to visually observe surface water accumulation pathways. In addition, the Site was observed following rain events for evidence of surface runoff and/or areas of accumulation.

One co-located surface-water and sediment sample was to be collected from an area to the west of the abandoned ICRR embankment (now dirt road) just north of the gate located north of the emergency containment pond. At this location, on May 1, 2007 during a Site visit, a seep was observed emanating from the sinter pile (also referred to the ash disposal area on historic Matthiessen and Hegeler Zinc Company maps). The water seeping out of the sinter was observed to accumulate along both sides of the dirt road with no apparent surface-water flow pathway. The sediment sample was collected at the seep location. No flow was observed at the seep location during Phase I. That seep location was again sampled in June 2009 as part of the Phase II sampling effort.

2.1.3.2 Phase II Surface Water and Sediment Investigation

Phase II of the Surface Water and Sediment Characterization Program was designed to further characterize sediment and surface water within the LVR, evaluate two point sources in OU2 to assess potential releases to the LVR, and characterize interstitial water from the Slag Pile/ LVR interface. The two point sources in OU2 are the ASO the CSO.

Sample analysis for sediment, surface water, and interstitial water included the 23 metals on the TAL with seven metals of potential concern (arsenic, cadmium, copper, lead, mercury, silver, and zinc) analyzed using US EPA Methods 6020A/7470A/7471B for low level analysis. These metals were selected primarily based on the results of the LVR sampling event performed during the Phase I investigation. Arsenic, cadmium, copper, lead, silver, and zinc were measured at levels above US EPA Region 5 Ecological Screening Levels (ESL) at one or more sediment or surface water locations. Mercury was added to the list for low level analysis due to US EPA's concerns about the presence of mercury and the

detection of mercury in Site media during previous investigations. Surface water and interstitial water samples were analyzed for hardness. Both total (unfiltered) and dissolved (filtered) surface water and interstitial water samples were collected and analyzed. Dissolved samples were filtered in the field.

At the time of surface water sample collections, field measurements of temperature, conductivity, DO, turbidity, pH, and ORP were recorded using a YSI 556 MPS with a flow-through cell and a turbidimeter. Surface water samples were collected as close to the sediment/surface water interface as possible using a decontaminated glass measuring cup. A new, decontaminated polyethylene measuring cup with an extended reach handle was used to sample surface water at LVR-409 because of deep water.

Sediment samples were collected using stainless steel spoons and bowls. Sieves were used to separate large grained material and large pieces of natural, organic material. All samples were immediately placed in an iced cooler until they were delivered to the laboratory under standard chain-of-custody.

A total of 19 sediment samples were collected from nine depositional areas within the LVR (LVR-401 through LVR-409), as shown in Figure 2.1.3-1. The locations for sediment sampling included:

- 1) Three downgradient of the Site (LVR-401, LVR-402, and LVR-403)
- 2) Two adjacent to the Slag Pile Area (LVR-404 and LVR-405)
- 3) One location downstream of the active CSO (LVR-406)
- 4) One location where the creek flowing from the ASO discharges to the LVR (LVR-407)
- 5) One upgradient of the dam sufficiently upstream to avoid potential impacts from the dam (LVR-408)
- 6) One upstream sample (LVR-409)

Two sediment samples located upstream of the Slag Pile (LVR-408, and LVR-409) were collected using a three-point composite approach within a single 10-ft diameter depositional area. Sediment types of different composition were combined into the same composite sample. Discrete sediment samples were collected from three locations downstream of the Slag Pile (LVR-401, -402, and -403), two locations adjacent to the Slag Pile (LVR-404 and -405), one location downstream of the active CSO (LVR-406), and one location within a depositional area where the creek flowing from the ASO to the LVR (LVR-407). Three discrete samples were collected at five locations (LVR-401 through -405) from 1) near the western bank; 2) near the center of the river; and 3) near the eastern bank.

A total of 27 surface water samples were collected from nine locations, including seven within the LVR (LVR-401 through -405, LVR-408, and LVR-409), one from the active CSO (CSO-410), and one from

the ASO (ASO-411), as shown on Figure 2.1.3-2. For all surface water samples, total (unfiltered) and dissolved (filtered) surface water samples were collected to evaluate the effect of particulates on metals concentrations.

Three discrete surface water samples were collected from five sampling locations, including three downgradient of the Slag Pile (LVR-401, -402, and -403), and two adjacent to the Slag Pile (LVR-404 and -405). For these locations, discrete surface water samples were collected equidistant across a transect perpendicular to the river (one near each bank and one in the center of the river). Two surface water samples (LVR-408 and -409) were collected using a three-point composite approach along a transect perpendicular to river flow. The three-point composite samples were equidistant across the transect (near each bank and in the center of the river). The samples were collected as close to the sediment/surface water interface as possible.

Discrete surface water samples were also collected from the active CSO and the ASO as follows:

- ASO. Four discrete surface water samples were collected from the point where the discharge tunnel empties into the creek leading to the LVR. The surface water samples were collected from the same location on four separate days. A flume was installed in the creek near the drainage tunnel and the flow rate was estimated at the time of sample collection. In addition, three discrete surface water samples were collected following qualifying rain events. A qualifying rain event is defined as a rainstorm that meets the following criteria: 1) produces 0.1 inches or more in measured rainfall in 24 hours; 2) causes an increase in runoff to be present at the outfall; and 3) occurs at least three days (72 hours) from the previous 0.1 inch rainfall.
- CSO. The surface water sample was collected at the point of discharge from the outlet to the river on three separate days.

A surface-water sample was collected during June 2009 from an area to the west of the abandoned ICRR embankment (now dirt road) just north of the gate located north of the emergency containment pond. At this location, on 1 May 2007, a seep was observed emanating from the sinter pile (also referred to the ash disposal area on historic Matthiessen and Hegeler Zinc Company maps).

2.1.4 Ecological Receptor Investigation

The Phase I and II ecological receptor investigations are discussed below.

2.1.4.1 Phase I Ecological Characterization

On October 23, 2007, Geosyntec conducted an ecological habitat characterization survey of OU1 by means of a pedestrian survey and visual observations. The ecological characterization survey of OU2 was also conducted that same day. Prior to conducting the survey, environmental and natural resource agency information sources were searched for any available literature pertaining to previous ecological studies that may have been conducted on the Site and adjacent areas, including the LVR. This search included a review of state and federally threatened or endangered species listings for LaSalle County.

The OU1 Phase I habitat characterization survey was conducted between 0700 and 1720 hours and consisted of two Geosyntec ecologists walking and observing portions of ecological habitats existing on the property. Weather during the survey was clear and cold. The visual survey provided for observations of flora and fauna as well as recent signs of animals (e.g., tracks, nests, middens, droppings, etc.) in the project area. Quantitative sampling/trapping/collecting of flora and fauna was beyond the scope of the habitat characterization activities. Taxonomic nomenclature for plants and wildlife described in this section were derived from a collection of appropriate field guides and web-based government databases (INHS 2008; USDA NRCS 2006; Tekeila 2006; Brockman 1968). Flora and fauna observed at OU1 are tabulated in Table E-G1-2 of Appendix RA-E-G1.

The habitat characterization was conducted to gather data necessary to investigate potential ecological receptors and developed a preliminary CSM for the OU1 SLERA. Habitat characterization activities focused on the three sub-areas areas of OU1: the active Carus Plant Area, the slag and related material disposal area located east of the active facility, and the LVR (Figure RA-G-3-1 in the SLERA). Within these sub-areas, Geosyntec investigated four habitat types:

- 1) Highly disturbed
- 2) Disturbed with vegetation
- 3) Riverine
- 4) Riparian

The observed habitats and wildlife characteristics of these sub-areas are described below.

The Carus Plant Area is an active industrial facility dominated by buildings and structures associated with the manufacturing processes. Limited areas of maintained grass or shrubs border the facility.

Groundcover consists primarily of concrete, gravel, and asphalt. No wildlife or overt animal signs were observed with the Carus Plant Area during the habitat characterization site visit.

Two water features that are integral to the operation of the Carus Plant are present just south and southeast of the Carus Plant on the Slag Pile. These features are two man-made ponds constructed and operated to provide spill prevention and control for Clean Water Act (CWA) compliance associated with the daily operations of the plant. Specifically, non-contact cooling water generated during the production of potassium permanganate is discharged to the ponds and eventually to the LVR under a NPDES permit. These ponds are not considered “waters of the United States” (i.e., not jurisdictional); rather, these ponds are regulated under the NPDES program and, therefore, not evaluated in the OU1 ERA.

The remaining upland terrestrial areas of OU1 consist of the Slag Pile, which has been disturbed from historical Matthiessen and Hegeler Zinc Company Site operations, primarily the handling and placement of slag. The Slag Pile is located east of the Carus Plant, along the banks of the LVR (Figure RA-G-3-1 in the SLERA). Relative to the natural landscape, this waste pile inherently represents highly disturbed habitat. The easternmost portion of the Slag Pile consists of steep slopes, which are mainly unvegetated, with the exception of lichen and moss growing along the low, moist areas adjacent to the river, and pioneering plants, including bladder-campion (*Silene vulgaris*) and an unidentified sedge (*Carex* spp.) that US EPA observed encroaching along the areas of exposed slag.

The areas of the Slag Pile with enough soil or organic material to support vegetation are colonized by patchy occurrences of bigtooth aspen (*Populus grandidentata*), red cedar (*Juniperus virginiana*), and cottonwood trees (*Populus deltoids*) with a sparse understory. Some upland forested habitat was observed interspersed among the slag disposal area comprised of young deciduous hardwoods including: American sycamore (*Platanus occidentalis*), red maple (*Acer rubrum*), birch (*Betula* spp.), honey locust (*Gleditsia triacanthos*), ash (*Fraxinus* spp.), sassafras (*Sassafras albidum*), various oaks (*Quercus* spp.), and hickories (*Carya* spp.). For the most part, these species were observed along the western fringe of the Slag Pile with the more mature woody species observed in a small area in the extreme southeast portion of OU1 along the LVR near the Highway 6 Bridge. Understory species included sagebrush (*Artemisia* spp.) and smooth sumac (*Rhus glabra*), and Japanese honeysuckle (*Lonicera japonica*) cover was observed on the uppermost portions of the Slag Pile where some organic material was present and well-drained. Other species included Atlantic poison oak (*Toxicodendron pubescens*) and poison ivy (*Rhus radicans*), and invasive exotic species such as bush honeysuckle (*Lonicera maackii*) and common buckthorn (*Rhamnus cathartica*).

Wildlife observed in terrestrial portions of OU1 (Slag Pile Area) included red-tailed hawk (*Buteo jamaicensis*), American crow (*Corvus brachyrhynchos*), American robin (*Turdus migratorius*), cedar waxwing (*Bombycilla cedrorum*), northern cardinal (*Cardinalis cardinalis*), English sparrow (*Passer*

domesticus), field sparrow (*Spizella pusilla*), and unidentified warbler species. Beaver (*Castor canadensis*) signs in the form of chewed tree stumps/stems were also observed in the southeast portion of the Slag Pile Area along with direct observations of white-tailed deer and their bedding areas and trails. Incidentally, a red fox (*Vulpes vulpes*) was observed off site near the Highway 6 Bridge at the southern perimeter of the Carus property.

The LVR sub-area of OU1 includes the extent of the LVR bordering OU1 and OU2, and extending south to its confluence with the Illinois River. As a result of historical slag disposal practices, slag material was observed along the western bank of the river at several locations. Slag encroachment into the river channel was evident in several areas as altering hydrology and resulting in channel re-alignment into the east bank of the river. Slag material was also observed in the channel of the river from the Site extending south from the Site (south of Highway 6 Bridge).

The major habitat type associated with the LVR is aquatic, although some sand and gravel islands located within the channel tend to be partially vegetated with grasses, shrubs, various forbs (broadleaf herbaceous plants), reeds, and wetlands vegetation tolerant of flooding.

Floodplain habitat is located on the eastern Site perimeter along the banks of the LVR. Review of the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map for the Site area, indicates that approximately 31.5 acres of the Site area located along the LVR are contained within Zone AE, the 100-year floodplain (Figure RA-G-3-2 of Appendix RA).

During the habitat characterization site visit, several areas bordering the river were observed to exhibit wetlands plant community characteristics. Based on review of the United States Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) Map for the Site and the vicinity, two wetlands areas are indicated along the LVR to the north of the OU1 Slag Pile Area (USFWS 2011). These wetlands are characterized as temporarily flooded and forested. The NWI indicates that extensive wetlands and riverine habitats are located downstream of the project area in the area of the confluence of the Illinois River and the LVR.

The LVR is the most ecologically valuable habitat associated with the Site. Aquatic habitat along the Carus property boundary accounts for approximately 14 surface acres. The river in the vicinity of the Site follows a steep gradient with fast-moving runs and riffles commonly observed along with some pool habitats. The river gradient flattens out once it meets the Illinois River floodplain near the Illinois and Michigan (I&M) Canal. Bottom substrates of the river consist of exposed bedrock, medium and large-

sized large rock, with gravel, cobble, and sand. Near its confluence with the Illinois River south of the Carus property, the river is surrounded by freshwater emergent wetlands and freshwater forested/shrub wetlands areas. The confluence is characterized as typical deltaic, exhibiting a broad, shallow sediment depositional area.

Sand or gravel bars or islands within the river channel are common features, especially along the bend located at the northeast property boundary. The banks can become vertical in areas where the river channel narrows and the river deepens across the entire reach. Throughout its length, the river exhibits signs of wretched vegetation (water mark) from periodic and perhaps seasonal flood flows. At the time of the survey, water was flowing in the channel approximately six to eight ft below the high water mark, as expected during periods of drought. The banks of the river in areas where the topography is sloping were observed to be well vegetated with grasses, shrubs, reeds, and moss. A 2004 sampling program by the Illinois Department of Natural Resources (IDNR) recorded an abundance of quality aquatic vegetation, including *Elodea sp.*, curlyleaf pondweed (*Potamogeton crispus*), and sago pondweed (*P. Pectinatus*), at sampling locations in the river near LaSalle (IDNR 2004).

Wildlife observations during the site visit indicated that aquatic habitat in the LVR has the potential to support a diversity of aquatic life such as insects, mussels, and fish; and, the river serves as a food source for mammals and birds including habitat for wading birds. Signs of wading birds were observed along the banks and in the shallow areas along the edges of the gravel and sand bar islands during the habitat characterization survey. Great blue heron (*Ardea herodias*) were observed flying above the river and feeding in the river during river characterization activities performed the day following the habitat characterization survey. Other bird species such as the red-tailed hawk and the American crow were observed flying above the river. Wood duck (*Aix sponsa*) were observed swimming in a deep, calm section of the river near the boundary with OU2. Beaver signs in the form of an active den on the river bank were observed during the habitat characterization survey, and beaver were observed swimming in the river during river characterization activities. Live and relic mussel species such as deertoe mussel (*Truncilla truncata*), plain pocketbook mussel (*Lampsilis cardium*), and white heelsplitter mussel (*Lasmigona complanata*) were observed in several areas of the river, particularly in shallow areas along the gravel and sand bar islands. A personal communication from an Illinois Natural History Survey biologist specializing in mussels indicated that other mussel species including the creek heelsplitter mussel (*Lasmigona compressa*) and the ellipse mussel (*Venustaconcha ellipsiformis*) have been observed in the LVR within the project area (Cummings 2007). Small gastropods were also observed in the areas where mussels were encountered. Specimens and egg cases of Ephemeroptera (mayfly) and Trichoptera

(caddisfly) were found under large rocks and slag material in shallow areas of the river. Sampling programs conducted by the IDNR upstream of the Site have generally concluded that quality riverine habitat supports a diverse fish population, and the presence of smallmouth bass, largemouth bass, sunfish, shiners, native suckers, and native minnow species (IDNR 2004; Carney 2001; Zimmerman 2001; IDNR 1999). Monitoring of the macroinvertebrate community conducted by the IEPA at the southern boundary of the Carus property near the Highway 6 Bridge indicates that a generally abundant and diverse community is supported (LaSalle County Soil and Water Conservation District 2003).

The near-bank riparian habitat along the LVR supports a plant community more adapted to periodic overbank flooding (floodplain) conditions, particularly in the low-lying area located directly north of the Highway 6 Bridge. Woody vegetation in this area is characterized by sycamore, red maple, eastern cottonwood (*Populus deltoides*), and river birch. American hornbeam (*Carpinus caroliniana*), osage-orange (*Maclura pomifera*), crabapple (*Malus sp.*), sumac, bush honeysuckle, and common buckthorn were also observed in the bottomland mixed-hardwood forest habitat occurring in the floodplain adjacent to the river. Ground cover exhibits characteristics of both upland and low, moist areas associated with the river. Ground cover vegetation in the floodplain habitat is characterized by grasses, herbaceous plants, poison ivy, ferns, wildflower species, common reed (*Phragmites australis*) and other species adapted to moist floodplain conditions.

Prior to performing the Site visit, Geosyntec obtained lists of endangered or threatened species known to occur in LaSalle County from the USFWS, IDNR, and from the Illinois Natural Heritage Database. Based on this review it was ascertained that at the county-wide level of information, the list of State and Federally listed threatened, endangered, or rare species that potentially occur in LaSalle County is extensive. Several of the State and Federally listed plant and animal species potentially occur at or near the Site based on their known distribution and/or habitat preferences. No protected species were observed at the Site during the habitat characterization survey.

An analysis of the habitats required by species listed as threatened and endangered in LaSalle County indicates that habitat that could potentially support listed threatened and endangered species is present in the project area. The LVR and adjacent forested floodplain areas contain some areas of habitat suitable for protected bat species such as the Indiana bat (*Myotis sodalis*); however, collection efforts in the corridor using mist nets yielded no specimens (ICCD 2007). The Indiana bat reportedly roosts in upland and floodplain forests near watercourses, which they use as foraging areas (INHS 2008). The LVR may also provide suitable habitat for the northern river otter (state threatened), sheepsnose mussel (state threatened; federal candidate species), and the greater redhorse, a state-endangered fish that prefers clear

waters of medium-sized rivers having sand, gravel or boulder substrates (INHS 2008). Numerous species of songbirds, such as Henslow's sparrow (*Ammodramus henslowii*) and waterfowl are known to nest, winter, or migrate through the LVR corridor. It should be noted that a USFWS news release dated June 28, 2007 reported that the bald eagle is no longer listed as endangered under the Endangered Species Act, although it is still protected under other federal laws that prohibit their "taking". Bald eagle was not observed at the Site during the habitat characterization survey.

2.1.4.2 Phase II Ecological Characterization

A river characterization program was developed as a component of the Phase II investigation to support the BERA being conducted for the LVR. The program included: 1) assessment of benthic and fish communities; 2) collection and analysis of additional sediment and surface water samples (see [Section 2.1.3.2](#) above); and 3) collection of fish and mussel tissue samples. Phase II community assessment and tissue collection activities were conducted by Geosyntec in August 2009. The activities were conducted in four reaches of the LVR, each a minimum of 330-ft (100-m); these are:

- Station CAR001 – this sample reach is located at the southern extent of the Slag Pile, approximately 0.10 river mile upstream of the 5th Street (State Route 6) Bridge and adjacent to the southern extent of the OU1 Slag Pile.
- Station CAR002 – located approximately 0.21 river mile upstream of the 5th Street Bridge and adjacent to the OU1 Slag Pile.
- Station CAR003 - located 0.44 river mile upstream of the 5th Street Bridge at the northern end of the OU1 Slag Pile. Though adjacent to the Slag Pile, CAR003 was established to measure primarily the potential effects of the ASO discharges associated with OU2 and the City of LaSalle CSO discharges, both of which discharge to the river within the CAR003 reach.
- Station CAR004 (Reference Reach) – located approximately 2.32 river miles upstream of the 5th Street Bridge and upstream of the Matthiessen and Hegeler Zinc Company Site.

A summary of the biological assessment is presented herein; however, the full Biological Assessment Report (BAR; Geosyntec 2011b) is included as Appendix RA-E-G3. The biological community assessment of the LVR at the Matthiessen and Hegeler Zinc Company Site generally followed the methodology outlined in the Site FSP Addendum No. 1, which was approved by US EPA and IEPA on May 4, 2009 (Geosyntec 2009b). The assessment was patterned after Illinois water and natural resource agency bioassessment protocols (IDNR 2001; IEPA 2007), which employ multi-metric "index of biotic integrity" IBI scoring systems to evaluate stream health.

For benthic macroinvertebrate community sampling, each reach was longitudinally divided into east and west halves, generally delineated by the stream thalweg, and sampling was conducted in each half of the four river reaches. Sampling points were evaluated based on habitat proportions for each half reach and sampling (individual jabs) was conducted using a standard long-handled D-frame dipnet (approximately 1-ft frame width) with 500 micron (μm) mesh netting. The samples were shipped to Pennington & Associates, Inc. laboratory for enumeration and taxonomic identification. The resultant macroinvertebrate community data were evaluated within and between each reach using the multi-metric approaches described in the BERA. As part of the macroinvertebrate community survey, additional effort was targeted towards determining the status of freshwater mussel populations in each sample reach. The freshwater mussel community was surveyed for the presence/absence of mussels at each sample reach via timed searches of one hour conducted by three personnel (total of 3 man-hour surveys).

Fish community sampling was conducted within the full length and width of each sample reach (i.e., split river design was only applicable to the macroinvertebrate samples). The fisheries survey was conducted within wadeable habitats of each reach using a non-electrified seine and a backpack electrofishing unit system. Block nets were established at upstream and downstream reach termini to restrict fish passage and allow for more accurate sampling of fish communities within the reaches. All reaches were sampled for 36 minutes to maintain a consistent sample collection effort within each reach. Electrofishing was conducted in a standardized fashion in a downstream to upstream direction and included all riffle, run, and pool habitats present.

In the conduct of fish and macroinvertebrate community assessment, selected fish and mussel species were retained for biotic tissue analysis to further support the BERA. Target species and number of samples (in particular, mussels) at each reach were modified in the field, based on availability/abundance; these included: 1) forage/preyfish species - Northern hogsucker (*Hypentelium nigricans*); 2) sportfish/predator species - smallmouth bass (*Micropterus dolomieu*) and sauger, (*Sander canadensis*); and 3) freshwater mussel species - plain pocketbook.

One prey fish species, one freshwater mussel species (where available), and one sportfish species were collected for biotic tissue analysis at each of the four established sample reaches. Although every effort was made to retain the same species across sample reaches, the sportfish species for CAR002 was limited to a whole body analysis of smallmouth bass. Live mussel specimens were rare for all sample reaches; only one plain pocketbook each was collected at CAR001, CAR002, and CAR003. Plain pocketbook species were not present at the reference reach (CAR004); only one specimen of ellipse was observed at this location. Because this species is listed as a species of special concern in Illinois, it was immediately

released. Although only one plain pocketbook was collected at each site reach, these specimens were retained and processed for tissue analysis. Note: in some instances, a single fish specimen yielded both fillet and whole body samples.

Composited biotic tissue samples were analyzed (using USEPA Methods 6010B/6020A/7471A) for the following metals: arsenic, cadmium copper, lead, mercury, silver, and zinc. These metals were selected primarily based on the results of surface water and sediment analyses for samples collected from the LVR during the CERCLA Phase I investigation.

2.1.4.3 Additional Ecological Characterization

In August 2011, Geosyntec collected sediment samples from the LVR for the purposes of conducting sediment toxicity testing. Sediment samples were collected from three LVR site reaches (CAR001, CAR002, and CAR003) and the upstream reference reach (CAR004) identified for Phase II sampling. Briefly, field personnel from Geosyntec, SulTRAC, and US EPA jointly investigated three depositional areas within each reach on the basis of accessibility and the presence of sufficient sediment. A composite sample was then collected from each depositional area (note that only two depositional areas were sampled in CAR001 due to access limitations and high river levels).

At each sampling location (i.e., depositional area), sediment was collected from the biologically active zone (approximately the top 15 cm of the river) using shovels and five-gallon buckets. Approximately two five-gallon buckets were collected from each depositional area and brought to the shoreline for sieving and dewatering. All sediment was passed through a one-millimeter (mm) stainless steel sieve into a five-gallon bucket where it was homogenized and decanted. Field personnel continued sieving, homogenizing, and decanting the samples to produce approximately three gallons of sediment which was suitable for sampling and analysis (meaning, sufficient solids based on visual inspection and best professional judgment). In two instances, additional material was sent to the laboratory due to the fine-grained nature of the material, which could not be sufficiently decanted in the field (LVR609 and LVR611). Two one-gallon buckets of the sieved and dewatered sediment material from each location were sent to EnviroSystems, Inc. Laboratories in Hampton, New Hampshire for toxicity testing. Sediment toxicity tests were conducted using a 10-day *C. dilutus* test for survival, weight, and biomass to represent possible acute effects and a 28-day *H. azteca* test for survival, weight, and biomass to represent possible chronic effects. In addition, split sediment samples were sent to Columbia Analytical Services, Inc. Rochester, NY for analysis of ammonia, cyanide, nitrogen, metals, PCBs, pesticides, SVOCs (including PAHs), VOCs, TOC, total solids, and grain size.

2.1.5 Air Sampling Investigation

High volume air sampling was conducted during Phase I activities at OU1 to monitor exposure and risks associated with arsenic, lead, and asbestos inhalation at the Matthiessen and Hegeler Zinc Company Site. The arsenic and lead air monitoring procedures followed the guidance provided in the Phase I Work Plan (Geosyntec 2007a), and the asbestos air monitoring procedures followed the guidance provided in the “Modification to Sampling Protocol for Asbestos in Air” technical memorandum (Geosyntec 2007b).

2.2 OU2 INVESTIGATION ACTIVITIES

The scope of the RI/FS activities at OU2 was developed with US EPA by synthesizing information from OU1 site investigation reports and reviewing historical records that SulTRAC procured from the industrial corporation archives at Northern Illinois University. RI scoping information directly related to OU2 was taken from Matthiessen and Hegeler Zinc Company Site fire insurance maps, aerial photographs, architectural drawings, site diagrams, engineering maps, laboratory notebooks, and other documents that describe building construction, operation details, and Matthiessen and Hegeler Zinc Company Site processes. Overall, the Matthiessen and Hegeler Zinc Company Site investigation activities were based on a prior OU2 sampling event involving the nine samples collected during the CERCLA integrated assessment ([Section 1.2.3.2](#)) and other available historical documentation.

Based on limited site information pertaining to contamination, SulTRAC proposed and the US EPA concurred that OU2 RI activities be divided into two phases (US EPA 2007). Phase I focused on characterizing the nature of Matthiessen and Hegeler Zinc Company Site contamination using a biased sampling approach, and Phase II focused on delineating the extent of contamination. The Phase II investigation activities also focused on filling any potential data gaps related to contamination characterization from Phase I using a grid for determining sampling locations or using random sampling locations. The RI/FS involved investigation and study of the former Rolling Mill and associated buildings, the shallow sinter and slag cover present over much of the Matthiessen and Hegeler Zinc Company Site, and surrounding residential areas that have been defined as OU2. The US EPA Field Environmental Decision Support (FIELDS) Team investigated the residential area. The goal of the residential sampling was to obtain the minimum amount of data necessary to support the selection of an approach for site remediation and then to use these data to allow a well-supported Record of Decision (ROD).

The Phase I field activities included collecting surface and subsurface soil samples from 196 borings; installing 19 MWs; collecting groundwater samples from the MWs; collecting building material samples from 10 buildings and structures; collecting surface water samples from 7 locations over two sampling events; and collecting 55 debris/hazardous waste pile samples. During Phase I, SulTRAC also conducted ecological investigations, including wetland and habitat delineation/function and value assessment, wildlife observations, and investigation of endangered species and other species of special concern. OU2 residential surface soil sampling and X-ray fluorescence (XRF) sampling were conducted by US EPA FIELDS.

Phase II field activities included collecting surface and subsurface soil samples from 60 borings; collecting building material samples from the remains of 50 buildings and structures; installing 17 additional MWs and 6 piezometers; performing on-site soil XRF screening at 160 locations and collecting soil samples based on XRF screening results; collecting soil, sinter, and slag pile samples for bioaccessibility testing; collecting vegetation, earthworm, and soil/sinter/slag samples for bioavailability testing; ecological soil sampling for lettuce seed germination bioassays to evaluate soil phytotoxicity; collecting groundwater samples from the existing and new MWs; collecting surface water samples from six locations over two sampling events; collecting 20 off-site surface soil samples for XRF screening and laboratory analysis; performing additional OU2 residential surface soil sampling and XRF screening and collecting asbestos air samples using the activity-based sampling (ABS) method.

The OU2 soil, groundwater, building material, pile, surface water, residential area/off-site area, ecological receptor, and air sampling investigations are discussed below.

2.2.1 Soil Investigation

The Phase I and II soil investigations at OU2 are discussed below. Figures 2.2.1-1 through 2.2.1-3 show soil sampling locations. Table 2.2.1-1 summarizes information for the samples collected.

2.2.1.1 Phase I Soil Investigation

During the Phase I field investigation, SulTRAC collected soil samples from 196 borings. The primary purpose of the Phase I sampling activities was to investigate the nature of contamination in the surface and subsurface of OU2. The boring locations were advanced at or near the locations of existing or former buildings, railroads, and the LVR (Figure 2.2.1-1). Locations near the buildings and railroads were selected because associated activities may have been sources of contamination at the Matthiessen and

Hegeler Zinc Company Site. Buildings identified as unlikely to have been the source of a release, such as offices, locker rooms, or parts storage areas, were not included in the Phase I sampling locations.

SulTRAC advanced 196 borings during a 5-week period from July 16 through August 16, 2007. Six soil borings were advanced near the LVR to assist in determining the nature of potential contamination in alluvial deposits near the river. Two additional locations were advanced for soil and deeper bedrock sampling (rotary drilling) for geological logging purposes (DB01 and DB02). Soil samples were not collected for chemical analysis from these two boring locations as further discussed in [Section 3.0](#) of this RI report. The 196 borings were advanced to 12 ft bgs unless refusal was encountered before 12 ft bgs. Table 2.2.1-2a summarizes the Phase I soil boring depths, sampled intervals, and lithologies. The two deep soil borings, DB01 and DB02, were advanced to 90 and 48 ft bgs, respectively.

Surface and subsurface samples were analyzed for total metals, cyanide, VOCs, SVOCs, PCBs, pesticides, and asbestos using appropriate US EPA methods as listed in Table 2.2.1-3. Only subsurface fill samples (2- to 12-ft-bgs interval) were analyzed for asbestos, not subsurface native soils or bedrock. The field geologist identified native soil versus fill material. There was no reason to believe that asbestos would have penetrated beyond the surface in native soils, only in soils that had been remobilized (fill) at the Matthiessen and Hegeler Zinc Company Site. Quality control (QC) samples (field duplicate, matrix spike, and matrix spike duplicate [MS/MSD] samples) were also submitted for analysis. Field duplicate and MS/MSD samples were analyzed at frequencies of 10 and 5 percent, respectively.

During the Phase I field investigation, surface and subsurface soil samples were collected from 196 borings at two depth intervals per boring. Before sampling activities began, public utility clearance was conducted. All soil borings were advanced using hydraulically driven, direct-push technology to collect soil samples from specific depths. All soil borings except three were sampled using a direct-push technology rig or a direct-push technology device mounted to an all-terrain vehicle (ATV) or pickup truck. The three other soil borings, SB117, SB118, and SB119, were hand-augered because vehicles could not access these locations. The two deep soil borings, DB01 and DB02, were sampled using a hollow-stem auger and then through rock coring using a mud rotary drill. All personnel conducting sample collection and geologic logging wore non-powdered nitrile gloves.

A field geologist logged all soil borings using the SulTRAC geologic logging forms (Appendix S-1). For each soil boring location, the following information was included on the logging form: site name, project name, boring number, drilling method, boring diameter, depth to water, date started, date completed, geologist's initials, drilling subcontractor name, and location sketch (with information adequate to find

the boring location if warranted) with a north directional arrow. During boring advancement, the following information was also recorded on the geologic logging form: lithologic description, time each interval was collected, depth (in 2-ft increments), drive interval, recovered interval, and organic vapor measurement collected using a PID. The lithologic description recorded for each interval included color, texture, and lithology. If slag, sinter, soil, or debris piles were encountered, this information was recorded. All soil boring sample identifications were entered for the appropriate depth interval in the log. All soil boring intervals were photographed with a tape measure for scale, and the sample identification and depth were written on a whiteboard. All photographs have been archived.

PID soil sample screening was conducted in the field as summarized below.

- After soil boring sample retrieval, each sample was split in half.
- A portion of the first half of the soil was collected for VOC analysis first and was divided between three 40-mL glass containers with polytetrafluoroethylene (PTFE) lined septa and open-top screw caps, preweighed, and containing a magnetic stir bar. These sample containers were then placed in an iced cooler for laboratory analysis.
- The second half of the sample was placed in a resealable plastic bag, and then the bag was sealed and vigorously shaken. After approximately 5 minutes to allow organic vapors to accumulate, the resealable plastic bag was shaken again. The PID probe was inserted through a small opening in the plastic bag, and the concentration displayed on the PID was recorded in field logbooks. After screening, the portion of the sample subjected to headspace screening was placed with the borehole cuttings for disposal.
- The remaining soil was placed in glass containers with Teflon-lined lids and placed in an iced cooler for the remaining laboratory soil analyses.

Boring samples were continuously collected from the vadose zone using a large-bore, dual-tube, stainless-steel sampler with a disposable acetate sampling tube. The sampler was pushed to the desired depth (from the surface to the total depth of the boring) and then retrieved to collect soil samples. Upon retrieval from the sampler, soil samples were divided based on sampling intervals for description, screening, and packaging (see Standard Operating Procedures [SOP] 005 and 054 in Appendix S-2).

Two 2-ft-long samples were collected from each soil boring location for laboratory analysis: one surface soil sample collected from 0 to 2 ft bgs and one subsurface soil sample collected from a 2-ft-long interval from 2 to 12 ft bgs. The surface sample and subsurface samples were labeled with an “A” or “B,” respectively, at the end of the identification number as indicated in Tables 2.2.1-1 and 2.2.1-2a. Samples

were selected for laboratory analysis from the intervals with the highest apparent contamination based on both field observations and PID screening results. When field screening results and observations did not identify an interval for sampling and analysis from 2 to 12 ft bgs, SulTRAC collected samples from the shallowest of the following: above the water table, above bedrock, or the 8- to 10-ft-bgs interval. Not enough soil was recovered from some borings for all analyses. Therefore, additional borings were advanced as needed immediately adjacent to the primary boring locations to collect sufficient soil volume for all analyses.

Samples for VOC analyses were collected first and placed directly into the appropriate sample containers to minimize volatilization. Samples for total metals analysis (the primary contaminant of concern) were collected next, followed by samples for cyanide, SVOC, PCB, pesticides, asbestos analyses (see SOPs 005, 054, 006, and 014 in Appendix S-2).

2.2.1.2 Phase II Soil Investigation

During the Phase II field investigation, SulTRAC conducted geological investigations and collected surface and subsurface samples through XRF screening and soil boring installation. The primary purpose of the sampling activities was to supplement contamination characterization that began during Phase I and to characterize the extent of contamination. A total of 160 locations were screened with the XRF analyzer. Samples from 50 of the 160 screened locations were submitted to a Contract Laboratory Program (CLP) laboratory for confirmatory analysis. SulTRAC collected surface and subsurface soil samples from 60 borings during the Phase II field investigation (Figure 2.2.1-2). The boring locations were selected to supplement Phase I soil sampling results or to provide information for areas with limited data. The Phase II screening and sampling activities are discussed in more detail below.

SulTRAC coordinated with US EPA's FIELDS Team to screen the 160 surface soil sampling locations using an Innov-X[®] XRF analyzer (Figure 2.2.1-3 and Table 2.2.1-1). This screening was conducted using an unbiased gridded sampling approach. US EPA identified the field sampling locations, which were located using the global positioning system (GPS) capability of US EPA's Rapid Assessment Tools (RAT). The purpose of the XRF field program was to gain high spatial-resolution metals concentrations for the following metals of interest (based on the Phase I results): arsenic, cadmium, lead, mercury, and zinc, especially in areas with limited access for direct-push vehicles.

The 160 surface soil samples were screened using the XRF analyzer on July 28 through 30, 2008. The XRF technology uses an x-ray tube source to irradiate samples with x-rays. For screening, each soil

sample was placed in a plastic bag using a clean, stainless-steel trowel, positioned in front of the probe window, and screened. The probe window was placed in direct contact with the plastic bag, mainly to preserve the XRF window quality (see SOP XRF in Appendix S-2).

With guidance from US EPA's FIELDS Team, SulTRAC selected samples from 50 of the 160 (Figure 2.2.1-3) screened locations for submittal to a CLP laboratory for confirmatory analysis for total metals and cyanide. The CLP laboratory results were then used to calibrate the XRF screening results for the 50 sampling locations to create a calibration curve against which all OU2 XRF data could be compared based on the US EPA sampling and analysis plan (SAP) (Weston 2006). Table 2.2.1-1 summarizes all XRF sample information.

All samples were packaged and transported to a central location and placed on ice for possible laboratory analysis. The US EPA FIELDS team organized all data collected from the XRF screening and recommended CLP laboratory total metals analysis for 50 samples that yielded a range of concentrations. Each of the 50 surface soil samples were then placed in 8-ounce glass jars and submitted to the CLP laboratory. QC samples (field duplicate and MS/MSD samples) were also submitted. Field duplicates and MS/MSD samples were analyzed at frequencies of 10 and 5 percent, respectively.

SulTRAC advanced the 60 soil borings on October 6 through 9 and October 14 through 17, 2008, to collect surface and subsurface soil samples from two depth intervals per boring. The surface and subsurface samples were collected using a biased approach at or near the locations of existing or former buildings, railroads, and the LVR. Before sampling activities began, public utility clearance was conducted. A private utility locator was used to scan the area around and inside the Rolling Mill. All soil borings were advanced using hydraulically driven, direct-push technology to collect soil samples from specific depths. A total of 30 borings were sampled using a direct-push technology rig, and a total of 28 borings were sampled using a direct-push technology device mounted on an ATV. Two soil boring locations (SB443 and SB445) in the northeastern periphery next to the LVR were sampled using a hand auger. A field geologist logged all soil borings using the SulTRAC geologic logging forms (Appendix S-1). All logging information, sampling procedures, and decontamination procedures were conducted in the same manner used during the Phase I field investigation ([Section 2.2.1.1](#)).

The 60 soil borings were advanced at the following locations (Figure 2.2.1-2):

- 1) 10 soil borings in the north area of OU2
- 2) 10 soil borings at the northeast periphery of OU2 between the former ICRR and the LVR
- 3) 10 soil borings in the former main industrial area

- 4) 10 soil borings around Building 100
- 5) 10 soil borings in the exterior northwest corner of the Rolling Mill
- 6) 10 soil borings inside the Rolling Mill

Fifty borings were advanced to 12 ft bgs unless refusal was encountered before 12 ft bgs. The remaining 10 soil borings, all located around Building 100, were advanced to depths greater than 12 ft bgs. In this area of PCB contamination, identified during the Phase I investigation, SulTRAC used a PCB-specific chemistry field analyzer (Dexsil Corporation 2006) to estimate PCB concentrations at depths greater than 12 ft bgs (see SOP PCB9078, Appendix S-2). The goal of this analysis was to continue direct-push technology activities to depths exhibiting no detectable PCB concentrations based on field analytical results. This “clean” deep horizon was then sampled, and samples were sent to the CLP laboratory for verification.

All surface and subsurface samples from the combined 30 soil borings in the north area, northeast periphery area, and inside the Rolling Mill were analyzed for total metals, cyanide, VOCs, SVOCs, PCBs, and pesticides. Surface samples were also analyzed for asbestos. All surface and subsurface samples from the 10 soil borings in the main industrial area were analyzed for total metals and cyanide, and these samples underwent the SPLP. Samples from five of these locations also underwent the TCLP. Samples from the 10 soil boring locations in the exterior northwest corner of the Rolling Mill and from the 10 soil borings located by Building 100 were analyzed for PCBs, total metals, and cyanide. Table 2.2.1-1 indicates which 10 samples (from five locations) were analyzed using the TCLP and which 20 samples (from 10 locations) were analyzed using the SPLP. Samples were analyzed using appropriate US EPA methods as listed in Table 2.2.1-3. QC samples (field duplicate and MS/MSD samples) also were collected as described above for the XRF surface soil samples.

During Phase II, a total of 188 surface and subsurface soil boring samples were submitted to the CLP laboratories for chemical analysis (except asbestos analysis). STAT Analysis Corporation analyzed samples for asbestos using the 400-point-count asbestos analysis method. Table 2.2.1-2b summarizes the Phase II soil boring depths, sampled intervals, and lithologies. All sampling procedures were conducted in accordance with SulTRAC’s SAP (SulTRAC 2008b).

2.2.2 Groundwater Investigation

Regionally, aquifers are represented by sands and gravels within surficial glacial deposits and the underlying permeable sandstone and limestone bedrock formations. The City of LaSalle has a municipal

well field approximately 0.75 mile south of the Matthiessen and Hegeler Zinc Company Site (IEPA 2004a). This well field derives water from the glacial sands and gravels at 60 to 70 ft bgs. The City of Peru has a municipal well field approximately 2 miles southwest of the Matthiessen and Hegeler Zinc Company Site (IEPA 2004b). This well field derives water from bedrock formations located at more than 2,000 ft bgs (IEPA 2004b). The groundwater investigation at OU2 focused on a much shallower water-bearing zone (WBZ) (at 20 to 50 ft bgs) and not on regional aquifers used by nearby municipal water supplies. As found during Phase I and Phase II activities, no glacial sands and gravel aquifers were found at depth and site related activities were not thought to impact an isolated aquifer 2,000 ft bgs. Prior to Phase I field investigation, because there was no existing information regarding groundwater at OU2, the locations of the 19 Phase I MWs initially were selected based on OU1 potentiometric groundwater maps, which indicate that groundwater flows east and southeast (Geosyntec 2006) and based on historic evidence of potential source areas and related contamination.

To investigate if groundwater has been impacted, SulTRAC installed a total of 36 MWs to investigate the nature of contamination within the water bearing zones. For Phase I, SulTRAC devised a network of 19 MWs to include upgradient MWs (on the Matthiessen and Hegeler Zinc Company Site), MWs in likely source areas (former main industrial area), and downgradient MWs (near the LVR) to characterize and delineate probable migration pathways for potential contaminants. To evaluate the extent of groundwater contamination and complete on-site groundwater characterization activities, SulTRAC installed an additional 17 MWs and six piezometers as part of the Phase II groundwater investigation. As part of the Phase II groundwater investigation SulTRAC also conducted slug tests to estimate site-specific hydraulic conductivity.

The Phase I and II groundwater investigations at OU2 are discussed below. Figure 2.2.2-1 shows the sampling locations. Table 2.2.1-1 summarizes information for the samples collected.

2.2.2.1 Phase I Groundwater Investigation

During the Phase I field investigation, SulTRAC installed 19 groundwater MWs, including wells MW01 through MW18 and one well cluster (MW02S and MW02D) (Figure 2.2.2-1). SulTRAC installed the MWs during a 5-week period from August 28 through October 2, 2007. All 19 MWs had 10-ft-long screened intervals completed at various depths either in fill, glacial drift, or Paleozoic shales.

Locations of the Phase I MWs were selected based on known or suspected on-site source contamination, geographic location (upgradient or downgradient), and assumed subsurface geology. The Phase I MWs

range in depth from 16 to 46 ft bgs and are screened in a variety of lithologies. Table 2.2.2-1 provides a MW installation summary. Quarterly groundwater sampling of the Phase I MWs commenced in November 2007 and continued in March, June, September, and December 2008, and March, June, and October 2009. Groundwater samples were collected to evaluate the nature and extent of contamination as well as to investigate potential groundwater contamination sources at OU2.

MW installation was performed using the hollow-stem auger and mud rotary drilling methods (see SOP020, 045, 054 Appendix S-2). Samples were collected continuously from 2-ft intervals for lithologic logging purposes. A field geologist logged all borings using the SulTRAC geologic logging forms (Appendix S-3). During drilling, the following information was recorded on the geologic logging form: time each interval was sampled, depth (in 2-ft increments), drive interval, recovered interval, blow count, and organic vapor measurement. The lithologic description also was recorded for each interval, including color, texture, and lithology. If slag, sinter, soil, or debris piles were encountered, these materials were specifically identified on the logging form and in the respective field notebook. All MW boring intervals were photographed, and the photographs have been archived.

The MWs were all constructed of 2-inch-diameter PVC well materials with 10-ft-long screens with a 0.010-inch slot size. The MWs were constructed with the well screen straddling the first encountered groundwater saturated zone. A clean filter pack was installed from the surface by pouring coarsely graded sand through a tremie pipe to the interval from 1 ft below to 1 to 2 ft (noted in MW construction logs) above the well screen (Appendix S-6). The sand was poured slowly, and the level of the sand was periodically tested with a weighted steel tape to prevent bridging. A 2-ft-thick seal of bentonite pellets was installed at the top of the filter pack, and the annular space from the top of the bentonite seal to the surface was filled with bentonite chips. Surface completion consisted of installing a concrete pad with a 4-inch-diameter steel outer protective casing that rises approximately 2 ft above grade. MWs were completed with expandable locking caps and three concrete bollards surrounding each MW location. After MW installation, a licensed surveyor surveyed the ground surface elevation, top of casing elevation, and horizontal location of all new MWs.

For each MW, the SulTRAC geologist recorded MW construction details on-site on SulTRAC MW completion forms. After installation, all MWs were developed prior to the first round of sampling following the Phase I SAP (SulTRAC 2007) and corresponding SOP 021 (Appendix S-2). Development consisted of surging and bailing the MW to remove fine sediments, followed by pumping to remove approximately five well volumes of water from each MW. MWs were considered developed when turbidity, DO, pH, temperature, and conductivity stabilized to within 10 percent over three consecutive

measurements taken at 5-minute intervals or if a minimum of five well volumes were removed and the water was visibly clear of suspended solids. These conditions typically indicate formation water from the water-bearing unit. MWs were sampled a minimum of 48 hours after MW development.

As discussed with the US EPA and outlined in the OU2 work plan (SulTRAC 2008c) and SAP for Phase I (SulTRAC 2007), SulTRAC collected samples from the 19 Phase I groundwater MWs using low-flow techniques (see SOP 010, 015, Appendix S-2). Based on the COIs, samples were analyzed for total metals, VOCs, SVOCs, PCBs, pesticides, and cyanide. QC samples, including field duplicate and MS/MSD samples, were collected during each groundwater sampling event. All sampling procedures followed the US EPA-approved SAP (SulTRAC 2007). Samples were analyzed using analytical methods listed in Table 2.2.1-3.

The planned groundwater sampling program for the initial four quarters for the Phase I MWs involved measuring groundwater elevations and sampling all MWs for total metals, VOCs, SVOCs, PCBs, pesticides, and cyanide. Table 2.2.2-2 indicates the MW sample analytes. Because of inadequate groundwater yield at times, samples from certain MWs could only be analyzed for priority analytes. Generally, groundwater samples for VOC analysis were collected first, followed by samples collected for metals, cyanide, SVOC, PCB, and pesticides analyses. However, when a MW did not yield enough groundwater to allow collection of the 8.12 liters needed to fill all sample containers for all analytes, the priority was to collect a sample for metals analysis first. If a MW was located near the Rolling Mill, sampling for VOCs and metals were a priority. For MWs near Building 100, sampling for metals and PCBs were a priority.

All groundwater samples were attempted to be collected using low-flow techniques (see SOP 010, 015, Appendix S-2). The low-flow method, also known as micropurging, minimizes colloid mobilization by removing water from the screened interval of the MW at a rate that preserves or minimally disrupts steady-state flow conditions in the WBZ. Each MW was purged at low flow rates until field parameters stabilized. Field parameters were considered stabilized after three successive measurements taken at a minimum of 3-minute intervals were within the following ranges: ± 0.1 standard unit for pH, ± 0.5 °C for temperature, ± 3 percent for conductivity, ± 10 mV for oxidation-reduction potential, and ± 10 percent for turbidity and DO. If the parameter stabilization ranges could not be met, samples were collected after three well volumes were purged as outlined in the Phase I and Phase II FSP portions of the SAPs (SulTRAC 2007 and 2008b). Table 2.2.2-3 summarizes all sampled MWs and their stabilization parameters.

Upon completion of the first four quarters of groundwater sampling for the 19 Phase I MWs, SulTRAC evaluated the data and presented US EPA with a Phase I groundwater technical memorandum (SulTRAC 2009a). The Phase I groundwater technical memorandum presents all Phase I groundwater analytical results and recommended future quarterly and yearly sampling (SulTRAC 2009a). SulTRAC recommended a reduction of analytical parameters on a well-by-well basis and the filtration of all groundwater samples in line using a 0.45- μ m filter because obvious particulate bias was associated with some metals analytical results, especially for metals with low aqueous solubilities (such as aluminum and lead). This recommendation was supported by high turbidities in some MWs (Table 2.2.2-3) likely related to the surrounding geological formation and low groundwater yield/recharge experienced in some MWs. This combination caused some difficulties in maintaining a constant and steady low-flow technique while collecting groundwater samples. Additionally, SulTRAC recommended that if a MW ran dry or near-dry after initial purging and filtered-metals sampling, sampling should resume the first thing the next morning, with no additional purging of the MW in order to obtain maximum groundwater yield for sample collection. This approach was recommended for all Phase I and II MWs that exhibited low recharge. This recommendation was made in an attempt to avoid further MW data gaps like those experienced during the first four quarterly sampling events (SulTRAC 2009a). US EPA accepted these changes to the Phase II sampling program, which began in December 2008.

Sampling and MW development activities for each quarterly sampling event from November 2007 through October 2009 for the Phase I MWs are summarized in Tables 2.2.2-1, 2.2.2-2, and 2.2.2-3.

2.2.2.2 Phase II Groundwater Investigation

To evaluate the extent of groundwater contamination and to supplement on-site groundwater characterization, SulTRAC installed an additional 17 MWs, MW19 through MW35, and 6 piezometers, Pz1 through Pz6 (Figure 2.2.2-1) at depths ranging from 15 to 36 ft bgs. Downhole geophysical logging (natural gamma) was performed on all new MW and piezometer borings. Slug tests were conducted at 12 MWs to estimate the hydraulic conductivity through the various lithological formations on-site. Explanation of the slug tests and the geophysical information obtained during MW installation is further discussed in [Section 3.3.2](#) and [3.3.3](#) of this RI report.

SulTRAC installed the additional 17 MWs and 6 piezometers during a 5-week period from July 14 through August 14, 2008. The MWs also were developed during this period. All MW installation processes, documentation, development, and sampling procedures were conducted in the same manner as

described above for the Phase I MWs ([Section 2.2.2.1](#), Appendix S-2). Table 2.2.2-1 provides a MW installation summary.

Downhole geophysical logging was conducted at all 17 MWs and 6 piezometers. SulTRAC used the Mount Sopris 2PGA-1000 (natural gamma) probe with the MATRIX portable digital data logger to record the geophysical test data. The Mount Sopris data logger recorded measured natural gamma ray data as the probe was lowered to the bottom of the borehole using the 4MXA-1000 winch system. The motorized winch system allowed for collection of continuous uniform data. Once the probe reached the bottom of the borehole, the winch system direction was reversed and as the probe was raised through the borehole, the data logger continued to record the measured geophysical data. After all the data were collected from the geophysical tests, the data were downloaded to a computer and input to an Excel spreadsheet for graphing. The graphs are then compared to the recorded boring logs for each borehole. The geophysical data are further discussed in [Section 3.3.2](#) of this RI report and shown in the site-wide cross-sections (Figures 3.3.2-1 and 3.3.2-2).

SulTRAC collected samples from the 17 new Phase II groundwater MWs in September and December 2008, as well as March, June, and October 2009. Based on the COIs, as detailed in the Phase I groundwater technical memorandum (SulTRAC 2009a) samples were analyzed for total metals, VOCs, SVOCs, PCBs, pesticides, and cyanide. QC samples, including field duplicate and MS/MSD samples, were collected during each groundwater sampling event. All sampling procedures followed the US EPA-approved SAP (SulTRAC 2008b). Samples were analyzed using the US EPA methods listed in Table 2.2.1-3.

The groundwater sampling program for the Phase II MWs involved measuring groundwater elevations and sampling all MWs for total metals, VOCs, SVOCs, PCBs, pesticides, and cyanide. MWs MW22 and MW28 had such low recharge rates that not enough water was produced to fill all sample vials for the necessary analyses. Table 2.2.2-2 summarizes the analytical parameters for each MW.

From the US EPA-approved groundwater technical memorandum, SulTRAC recommended slight alterations to future quarterly sampling events (SulTRAC 2009a). SulTRAC recommended that all groundwater samples collected from both Phase I or Phase II MWs for dissolved metals analysis be filtered using in-line 0.45- μ m filters as described in [Section 2.2.2.1](#). Additionally, SulTRAC recommended that if a MW ran dry or near-dry after initial purging and filtered-metals sampling, sampling should resume the first thing the next morning, with no additional purging of the MW in order to obtain maximum groundwater yield for sample collection.

The low-flow techniques discussed in [Section 2.2.2.1](#) were used to collect groundwater samples from all MWs (see SOP 010, 015, Appendix S-2). Table 2.2.2-3 summarizes all sampled MWs and their stabilization parameters.

MW development and sampling activities for each quarterly sampling event of the Phase II MWs from September 2008 through October 2009 are summarized in Tables 2.2.2-1, 2.2.2-2, and 2.2.2-3.

On October 28 through 31, 2008, SulTRAC conducted slug tests in 12 MWs: MW06, MW09, MW15, MW17 through MW20, MW23 through MW25, and MW29 (see SOP Slug Test, Appendix S-2). At least three slug tests were performed at each MW. Table 2.2.2-4 summarizes the number of slug tests conducted at each MW, the start and stop times for each test, depth to bottom, the initial water levels before conducting each slug test, and the type of slug tests conducted. SulTRAC used the Aquistar PT2X (50 PSI) data logger to record the slug test data. A 1.5-inch diameter by 3 ft long Geotech Well Slug, which displaces ¼ gallon of water, was used to conduct the slug tests. At several locations, a disposable PVC weighted bailer (1.6-inch diameter by 3-ft long), was used to perform a falling head slug test. A Solinst 100-ft water level indicator was used to collect water level and MW depth measurements. The Geotech Well Slug and water level indicator were decontaminated with Alconox® and water before conducting slug tests at a new MW location. The Aqua4Plus Version 1.6.10 software was used to execute/terminate the slug tests, to set up the frequency of data recorded, and to extract the water level readings and time from the data logger. Upon completion of each slug test, the data were extracted from the data logger onto the laptop computer to verify that the tests were conducted smoothly and the data were usable before beginning the next slug test. The start date and time, finish date and time, depth to bottom, initial depth to water, and depth to water after insertion of the data logger for each MW were recorded in the field notebook and are presented in Table 2.2.2-4. At each MW, the slug test SOP was followed (Appendix S-2).

After all the data were collected from the slug tests, the data were filtered to include the relevant change in hydraulic head within the MW. Some data at the end of the slug tests were eliminated because the test ran longer than necessary. Once the data were filtered, the Hvorslev method was used to calculate the hydraulic conductivity for each test. Details and calculations of the Hvorslev method can be found in Appendix S-4. The results of the slug tests are discussed in [Section 3.3.3.1](#) of this RI report.

2.2.3 Building Material Investigation

To evaluate the nature of contamination at OU2, building materials were sampled because they are potential sources of contaminants. The primary purpose of the sampling activities was to investigate the nature of contamination in the solid matrices at OU2 for possible future disposal. The Phase I and II building material investigations at OU2 are discussed below. Figures 2.2.1-1 and 2.2.1-2, respectively, show the Phase I and II building material sampling locations. Table 2.2.1-1 summarizes information for the samples collected.

2.2.3.1 Phase I Building Material Investigation

During the Phase I field investigation, SulTRAC collected 10 building material samples on August 9 and 16, 2007, that included concrete, various brick types, and stone (Figure 2.2.1-1). The building material samples were collected from recognizable buildings and building structures as well as piles of building materials because building materials may have become contaminated from Site operations. All building material samples were collected as surface grab samples and analyzed for metals, VOCs, SVOCs, PCBs, and pesticides using the US EPA methods listed in Table 2.2.1-3. All building material sample identification numbers have the prefix “BM” before the three-digit sampling location number.

The grab building material samples were collected using stainless-steel or disposable spades, shovels, or scoops whenever possible. Other tools, such as hammers, chisels, saws, or other cutting tools, were used depending on the building material sampled. All tools were pre-cleaned using a non-phosphate cleanser and deionized water rinse. If the sample was not granular or “scoopable,” SulTRAC personnel collected the sample wearing non-powdered nitrile gloves and attempted to homogenize the material as much as possible in the field except for samples analyzed for VOCs, which were submitted as whole pieces of materials. The procedures used to collect scoopable grab samples are summarized below.

- A pre-cleaned scoop or trowel was used to remove vegetation, and then the desired volume of solid was collected from the sampling area.
- The discrete grab sample was transferred to a glass sample container.
- If the sample was too large to fit into the glass container, attempts at manual homogenization were made or using a pre-cleaned hammer to break up the solid.
- The lid of each sample container was screwed on as the container was filled, and the exterior of the container was cleaned to remove any residue from overfilling.

- Glass sample containers were labeled and tagged, and appropriate information was recorded on soil sample data sheets (such as sampling depth, location, color, and other observations).
- The glass sample container was placed in a resealable plastic bag, and the container was placed in an iced cooler maintained at a temperature of 4 °C or lower.

Building samples collected for VOC analysis were not placed in containers consistent with US EPA SW-846 Method 5035. Instead, the same procedures described above were used for these samples. All samples were submitted to a CLP laboratory except for samples to be analyzed for asbestos. Asbestos samples were submitted to an independent laboratory for analysis.

2.2.3.2 Phase II Building Material Investigation

Fifty building material samples (brick, concrete, wood, stone, and other) were collected at the Matthiessen and Hegeler Zinc Company Site during Phase II, primarily to evaluate future waste disposal criteria (Figure 2.2.1-2). During the week of July 21, 2008, SulTRAC collected the building material samples, which were analyzed for total metals, cyanide, SVOCs, PCBs, pesticides, and asbestos. Of the 50 samples collected, 5 underwent VOC analysis and 5 underwent TCLP analysis. The building material samples were collected as grab samples and analyzed using the US EPA methods listed in Table 2.2.1-3. All sample material types (brick, concrete, wood, stone, etc.) were recorded in the field notebook. All samples were photographed, and all sampling locations were recorded in the field notebook. Sampling locations later were surveyed by professional surveyors.

Grab samples were collected using the same procedures described in [Section 2.2.3.1](#) except for the following differences: 1) ziplock-type bags were used as sample containers instead of glass containers; 2) all samples except those to be analyzed for total metals, cyanide, and asbestos were wrapped in clean aluminum foil; and 3) all samples were placed in a secondary ziplock-type bag (double-bagged). All wood and stained samples were sampled for VOCs. For samples collected specifically for VOC analyses, oversized material was obtained. SulTRAC instructed the CLP laboratory to collect sub-samples of these materials for VOC analysis. For the 50 samples of building material analyzed for SVOCs, PCBs, and pesticides, SulTRAC instructed the CLP laboratory to homogenize and grind the samples into pieces as small as possible for extraction and modified analysis. Building material samples analyzed for total metals and asbestos were collected whole and placed directly into ziplock-type plastic bags (without aluminum foil) and submitted to the laboratory for homogenization, grinding, extraction, and modified analysis. The samples analyzed for asbestos were sent to a subcontracted (non-CLP) laboratory.

2.2.4 Pile Investigation

To evaluate the nature of contamination at OU2, debris and waste piles were sampled because they are potential contaminant sources. The primary purposes of the sampling activities were to investigate the nature of contamination in the solid matrices at OU2 and to investigate potential disposal options for the FS.

SulTRAC collected 55 debris and waste pile samples on July 18 and 19 and August 2 and 6, 2007 (Figure 2.2.1-1). Table 2.2.1-1 summarizes information for the samples collected. All debris and waste pile samples were collected as surface grab samples and have sample identification numbers with a prefix “P” before the three-digit sampling location number. All debris and waste pile samples were analyzed for total metals, VOCs, SVOCs, PCBs, pesticides, and asbestos using the US EPA methods listed in Table 2.2.1-3.

Samples were collected for VOC analyses first and placed directly into glass sample containers, leaving no headspace, followed by sample collection for metals, SVOC, PCB, pesticides, and asbestos analyses (see SOP 007 in Appendix S-2). The same sampling procedures used during the Phase I building material investigation were used to collect the debris and waste pile samples ([Section 2.2.3.1](#)). All samples were sent to a CLP laboratory for analysis as described above except for samples analyzed for asbestos, which were submitted to an independent laboratory.

2.2.5 Surface Water Investigation

SulTRAC collected surface water samples during two separate events for both Phase I and Phase II RI activities (see SOP 009, Appendix S-2). The purpose of the Phase I surface water sampling events was to investigate whether precipitation events influence surface water at the Site (during the same season), and the Phase II surface water sampling events were conducted to test seasonal variations.

The Phase I and II surface water investigations are discussed below. Figure 2.2.5-1 shows the Phase I and II surface water sampling locations. Table 2.2.1-1 summarizes information for the samples collected.

2.2.5.1 Phase I Surface Water Investigation

During the Phase I field investigation, SulTRAC collected 13 surface water samples from seven locations during two separate events. The first surface water investigation was conducted on July 24, 2007, when surface water samples were collected to represent “dry” weather conditions. The second set of surface

water samples was collected on August 8 and 15, 2007, during “wet” weather conditions during a rain event (within 24 hours after a rain event). All surface water sample identification numbers have the prefix “SW” before the three-digit sampling location number. Surface water samples collected during the rain event have the suffix “W” after the three-digit sampling location number (Figure 2.2.5-1 and Table 2.2.1-1).

Surface water samples were collected from: 1) three locations from flowing ephemeral or intermittent streams (SW001, SW003, and SW004); 2) one location in a standing body of water from the overflow basin surrounding an aboveground storage tank (AST) (SW002); and 3) one each from the source of the abandoned sewer line (SW005) and from the middle (SW006) and mouth (SW007) of the associated stream that flows from the abandoned sewer line into the LVR. Seven samples were collected during the “dry” event, and six of these locations were resampled during the “wet” event (location SW001 contained no standing water during the “wet” sampling event). Samples were analyzed for total metals, VOCs, SVOCs, PCBs, and pesticides using the US EPA methods listed in Table 2.2.1-3.

Surface water samples were collected directly into sample containers. The opening of the container was oriented up, and the container was slowly submerged beneath the surface of the water and allowed to fill. If the sample container was too large to submerge, an intermediate container, such as the container lid, was used for sample collection.

The sample containers designated for VOC analyses were checked for air bubbles. If air bubbles were present, additional surface water was collected in the bottle cap and slowly poured into the container to remove air bubbles. The container then was recapped and checked again for air bubbles. This procedure was repeated until no air bubbles were present (see SOP 009 in Appendix S-2).

Samples for VOC analyses was collected first and placed directly into the appropriate sample containers leaving no headspace, followed by sample collection for metals, SVOC, PCB, and pesticides analyses (see SOP 009 in Appendix S-2). All samples were immediately placed in an iced cooler and maintained at a temperature of 4 ± 2 °C, without freezing, until they were delivered to the laboratory under standard chain-of-custody protocol.

2.2.5.2 Phase II Surface Water Investigation

During the Phase II field investigation, SulTRAC collected 11 surface water samples from six locations during two separate events (Figure 2.2.5-1). The first surface water investigation was conducted on July 9, 2008, when SulTRAC collected surface water samples during the summer season. The second set

of surface water samples was collected on October 30 and November 3, 2008, during the autumn season. All surface water sample identification numbers have the prefix “SW” before the three-digit sampling location number (Figure 2.2.5-1 and Table 2.2.1-1).

The originally proposed sampling locations included three drainage pipes in the northeast corner of the Site (SW015, SW016, and SW017), the source (SW012) and mouth (SW013) of the stream emanating from the abandoned sewer line, a seasonal “pond” in the north area (SW014) where standing water is often witnessed, and two locations at which discharge occurs from the main industrial plant area (SW010 and SW011).

During the July 2008 sampling event, because of the heavy vegetation, the three drainage pipes in the northeast corner could not be found and were not sampled. A total of five surface water locations were sampled. Samples were analyzed for total metals, VOCs, SVOCs, PCBs, pesticides, and cyanide. During the October 2008 sampling event, two of the three drainage pipes were located. However, they were dry and therefore not sampled. One additional location, former acid tank No. 9 (SW018), was added to the October 2008 sampling event (Figure 2.2.5-1) at the request of US EPA. During the October 2008 event, four of the surface water locations were resampled (SW010 was dry and not sampled) and one location (SW018) was added and sampled. Samples were analyzed for total (unfiltered) and dissolved (field filtered at the request of US EPA) metals, VOCs, SVOCs, PCBs, pesticides, cyanide, and total hardness (at request of US EPA) using the US EPA methods listed in Table 2.2.1-3.

Sample collection was conducted using the same procedures as those described in [Section 2.2.5.1](#). Additionally, all surface water sampling locations were photographed with a tape measure for scale and with the sample identification, sampling date, and north arrow written on a whiteboard. These photographs have been archived. The sample collection method, sampling date, sampling time, ambient temperature, and visual water characteristics were documented in the field notebook. A peristaltic pump (Geopump®) was used to pump surface water through in-line 0.45- μm filters to collect samples for dissolved metals analysis.

In addition to the Phase II surface water sampling, on November 20, 2008, Tri-County Locators of Leaf River, Illinois, conducted a camera survey of the abandoned underground sewer line along the southern portion of the former main industrial area. The purpose of this survey was to evaluate the condition of the abandoned sewer line, confirm historic reports and maps concerning the sewer line’s internal dimensions and construction, and locate manholes #1 through #7 (Figure 2.2.5-1). The abandoned sewer line runs east to west across the southern portion of the former main industrial area of OU2 and ends at a stream

that joins the LVR. Before the formal survey, only manholes #7 and #6 were found because they were visible at ground surface. During the survey, video cameras could not enter manholes associated with the abandoned sewer line because manhole #7 was collapsed and filled with debris and soil and manhole #6 was concreted shut. Therefore, the survey team decided to enter the abandoned sewer at the source of the stream that empties into the LVR and continue underground approximately 220 linear ft up a shallow slope to manhole #1 (Figure 2.2.5-1). This portion of the survey indicated that the abandoned sewer line was constructed of brick and mortar, indicated that water was seeping through the mortar, and confirmed the internal dimensions of the abandoned sewer line.

The entrance of the sewer line at the source of the stream that empties into the LVR was approximately 6 ft high and discharging water at a steady rate of 20 gallons per minute (GPM). At approximately 40 ft into the sewer line, a rise in the floor decreased the height of the opening to approximately 4 ft 6 inches by approximately 6 ft in diameter, and water was steadily flowing through the mortar and over the rise in elevation, causing a waterfall effect. Continuing through the sewer, the water flow decreased, although water could still be seen seeping through mortar and in and around the brick-lined sewer. At approximately 205 ft into the sewer, a manmade wood post measuring about 4 inches in diameter was observed next to a pile of bricks. It was established that the post and bricks were from a manhole which had collapsed from above and that the collapsed manhole was manhole #1. The underground survey was then concluded.

The sewer line survey then continued aboveground to attempt to locate the manholes. Because of the heavy vegetation, manhole #1 could not be located. Moving forward using a historic map for reference, the survey team located manholes #2 and #3 as circular indentations about 4 ft in diameter. However, these areas were probed unsuccessfully using a magnetic locator to verify the existence of metal manhole covers. Manholes #4 and #5 were not located, although these manholes seemed likely to be located in a wetland-type area that contained ample water and tall reeds. The water in this area was estimated to have a maximum depth of 4 ft and covers an area of about 0.5 acre. Based on the location of the water-covered area and the probable manhole locations, this area may be the main source of water observed steadily flowing from behind the collapsed area of the sewer line during the underground portion of the survey. Manhole #6 was located but could not be opened with a manhole hook for the video camera survey because the manhole was sealed with concrete. The inspection team then returned to manhole #7 to confirm earlier findings from the beginning of the survey.

Historic notes and reports of the sewer line indicate that the abandoned and retired line had been capped or sealed off by the City of LaSalle and replaced by a newer sewer line running through the Matthiessen

and Hegeler Zinc Company Site. This new sewer line is visible throughout the property and constructed of 100 percent pre-cast concrete. The new line is not brick-lined like the retired and abandoned sewer line. The survey of the new sewer line continued to the western boundary of OU2 at Sterling Street. A manhole was found that was much deeper than the newer manholes along Sterling Street. This manhole did not contain much water and had no water flow or movement. The manhole was constructed of brick-and-mortar-lined walls, approximately 20 ft deep, and in line with manhole #7. The aboveground survey findings confirmed that the abandoned sewer line is blocked off and no longer used.

2.2.6 Residential Area/Off-Site Area Investigation

The residential area investigation included surface soil sampling as well as XRF screening in the northern, southern, and western residential areas of the Matthiessen and Hegeler Zinc Company Site. Additional off-site area surface soil sampling was conducted east of the Site and the LVR to investigate the potential presence of airborne contamination in surface soil. The residential area investigations were conducted during Phase I and Phase II, and the eastern off-site area investigation was conducted during Phase II only.

The Phase I and II residential area/off-site area investigations are discussed below. Figure 2.2.6-1 shows the Phase I and Phase II residential area/off-site area XRF screening and surface soil sampling locations.

2.2.6.1 Phase I Residential Area/Off-Site Area Investigation

As part of the Phase I investigation, the US EPA FIELDS Team conducted the residential area investigation in April 2007 using its START contractor, Weston. The objective of this investigation was to study the presence and concentrations of metals, primarily lead and zinc, in shallow soil (0 to 6 and 6 to 12 inches bgs) in residential areas surrounding the Matthiessen and Hegeler Zinc Company Site.

The US EPA FIELDS Team devised a sampling grid to select XRF metals screening locations. Three grids were created: 1) one high-density grid with 97 locations (closest to the Matthiessen and Hegeler Zinc Company Site); 2) one medium-density grid with 28 locations; and 3) one low-density grid with 11 locations (farthest from the Matthiessen and Hegeler Zinc Company Site). Soil samples were collected for XRF screening from approximately 0 to 6 inches bgs using a five-point composite soil sampling procedure (Figure 2.2.6-1 and SOP XRF, Appendix S-2). The US EPA FIELDS Team also logged all sampling locations using a GPS unit combined with its RAT to integrate GPS and XRF metals results in the field. Of the XRF-screened soil samples, 20 percent were submitted to a CLP laboratory for total metals analysis. At approximately 10 percent of the sampling locations (14 locations), four-point drip-

zone composite samples were collected. At 20 percent of the sampling locations, additional soil samples were collected from 6 to 12 inches bgs. The fixed laboratory analytical results then were used to calibrate the XRF results for all soil samples screened using the XRF analyzer, creating a calibration curve against which residential surface soil XRF data could be compared in accordance with the US EPA FIELDS SAP (Weston 2006).

The XRF screening procedures are described in US EPA's SAP (Weston 2006) and in SOP XRF (Appendix S-2). The XRF screening procedures are summarized below.

- A five-point composite soil sample was collected from 0 to 6 inches bgs using a tulip bulber at each sampling location. All five samples were placed into a stainless-steel bowl and homogenized.
- A five-point composite soil sample was collected from 6 to 12 inches bgs using a corer at each sampling location. All five samples were placed into a stainless-steel bowl and homogenized. These samples were collected from approximately 20 percent of the residential yards sampled.
- A four-point drip zone composite soil sample was collected from 0 to 6 inches bgs using a tulip bulber at each sampling location from soil near the sides of the residential structures. All four samples were placed into a stainless-steel bowl and homogenized. These samples were collected from approximately 10 percent of the yards sampled.
- The samplers and associated equipment that contacted the samples were decontaminated between sampling collections using an Alconox® decontamination solution and rinsed with distilled water.
- All soil samples were screened using a portable XRF analyzer (Niton XLp-712 "gun").
- Off-site soil sampling was not conducted during Phase I activities.

2.2.6.2 Phase II Residential Area/Off-Site Area Investigation

Phase II off-site area surface soil collection and XRF screening were conducted by US EPA FIELDS Team and SulTRAC along the eastern banks of the LVR in May 2009. The purpose of the off-site sampling was to investigate if airborne contaminants from the Matthiessen and Hegeler Zinc Company Site had been deposited to surface soil. Phase II residential surface soil sampling occurred during two additional field events. The first event occurred in August and September 2009 at residential properties within two blocks of the western property boundary of the Matthiessen and Hegeler Zinc Company Site. The US EPA FIELDS Team conducted this event to close potential data gaps for areas near the Matthiessen and Hegeler Zinc Company Site. The second event occurred in March 2010 to further

investigate the presence and concentrations of metals, primarily arsenic, in shallow soil in the residential area surrounding the Matthiessen and Hegeler Zinc Company Site. SulTRAC and the US EPA FIELDS Team further investigated the extent of contamination by using a CLP laboratory to analyze samples instead of the previously used field method of XRF screening to obtain lower detection limits, particularly for arsenic.

On May 13, 2009, SulTRAC and the US EPA FIELDS Team collected surface soil samples and conducted XFR screening at 20 locations along the eastern bank of the LVR (Figure 2.2.6-1). The soil samples were collected from the Illinois Cement Company's property, and the sampling team was escorted by a representative of the Illinois Cement Company during the event. Before collecting the samples, the US EPA FIELDS Team devised a triangular sampling design consisting of 20 unbiased sampling locations. The US EPA FIELDS Team navigated the sampling team to each sampling design point using a Garmin 18x GPS unit and RAT software. At each location, SulTRAC removed surface vegetation and organic material using gloved hands and then used a trowel to acquire a soil sample from 0 to 6 inches bgs. The surface soil sample then was placed in a labeled, plastic resealable bag. The GPS location for each soil sampling location was recorded using the RAT software. At each new sampling location, the trowel was decontaminated using an Alconox® solution and water.

All soil samples were brought back to a central location for screening using an XRF analyzer, and results were recorded using the RAT software. After XRF screening, the surface soil sample was placed in an 8-ounce glass jar, wrapped, and submitted to a CLP laboratory for total metals analysis. All 20 surface soil samples as well as 2 duplicate samples were submitted for total metals analysis by the CLP laboratory. Field logbooks notes and photographs were recorded and archived as described in the Phase II SAP (SulTRAC 2008b).

On August 31 and September 1, 2009, the US EPA FIELDS Team conducted additional XRF screening and surface and subsurface soil sampling at 38 residential properties within two blocks of the western property boundary of the Matthiessen and Hegeler Zinc Company Site (Figure 2.2.6-1). The US EPA FIELDS Team concentrated on investigating high concentrations of lead. A five-point composite surface soil sample was collected from one residential yard (back, front, or side yard). The five-point composite soil samples were collected in the same manner described for the Phase I samples ([Section 2.2.6.1](#)). The composite surface soil sample was placed in a plastic resealable bag and screened using the XRF analyzer. If the XRF analyzer estimated lead concentration exceeded 400 parts per million (ppm), a subsurface five-point composite sample was collected from 6 to 12 inches bgs. A total of 38 surface and 9 subsurface samples were screened using the XRF analyzer and submitted to a CLP laboratory for total

metals analysis. Field logbook notes and photographs were recorded and archived as described in the Phase II SAP (SulTRAC 2008b).

On March 16 and 17, 2010, SulTRAC and the US EPA FIELDS Team sampled surface soil (0 to 6 inches bgs) at 25 residential properties. The residential surface soil sampling locations were selected from a grid developed by the US EPA FIELDS Team. The grid was created based on an adaptive fill sample design using Phase I and Phase II 2007 and 2009 residential area laboratory value sampling locations in LaSalle, Illinois. Specifically, the US EPA FIELDS Team's "adaptive fill secondary sampling module" tool in ArcGIS was used. A polygon was drawn around the residential area of interest to be sampled, and the model identified 25 potential sampling locations. US EPA sent out multiple access agreements per potential sampling location, and SulTRAC collected surface soil samples from one of the access-granted properties per modeled sampling location. SulTRAC conducted the residential surface soil sampling while the US EPA FIELDS Team navigated the sampling team to each residential property and recorded the specific sampling locations using a Garmin 18x GPS unit and RAT software. Surface soil residential area sampling procedures were consistent with those originally outlined in 2006 by the US EPA FIELDS Team and its contractor, Weston, and subsequently used during the previous residential and off-site area surface soil sampling events (Weston 2006). This sampling procedure is described above in [Section 2.2.6.1](#) and in the Phase II SAP Addendum #2 (SulTRAC 2010). This consistency in the sampling procedure ensured the comparability of analytical data with past data obtained during the 2007 and 2009 sampling events.

During this event, all 25 five-point composite samples as well as QC samples were sent to a CLP laboratory and analyzed using the CLP ILM05.4 inductively coupled plasma (ICP)/atomic emission spectroscopy (AES) method for soils to achieve a contract-required quantitation limit (CRQL) of less than or equal to 1 mg/kg for arsenic. XRF screening was not performed on any soil samples during this March 2010 sampling event because the XRF analyzer's detection limit for arsenic is 10 ppm, which is not substantially low enough to allow comparison of XRF data to any US EPA RSLs or similar screening levels.

At all sampled properties, at least one photograph was taken showing the address as well as one additional photograph depicting the soil sampling at each specific property. Logbook notes and photographs were taken and archived following the protocols described in the Phase II SAP (SulTRAC 2008b).

2.2.7 Ecological Receptor Investigation

The Phase I and II ecological receptor investigations are discussed below.

2.2.7.1 Phase I Ecological Receptor Investigation

On October 22 and 23, 2007, SulTRAC personnel conducted Phase I field investigations to evaluate ecological habitats at the Matthiessen and Hegeler Zinc Company Site. The purpose of the habitat evaluation was to gather data necessary to investigate potential ecological receptors and develop a CSM for the ERA. A preliminary CSM was developed prior to Phase II field activities at OU2. Specifically, SulTRAC evaluated the following parameters:

- 1) Water features and wetlands
- 2) Habitat types
- 3) Sensitive environments
- 4) Soils and land use
- 5) Wildlife species

Residential properties border the Matthiessen and Hegeler Zinc Company Site on the west and south, and industrial properties border the Site to the north and east across the LVR. Between the LVR and the developed industrial operations area to the west, the topography becomes steep, with shale and limestone outcrops. Out of the river valley, the property is extremely disturbed from past facility operations. The Site contains numerous slag deposits, pits at excavated building foundations, a former railroad spur, and in-ground former sulfuric acid tanks. All these disturbances have created a rough, unnatural topography. Alterations in the local topography have subsequently altered on-site drainage networks. Using aerial photographs and detailed land surveys, SulTRAC investigated all identified potential water features. In addition to the LVR, SulTRAC observed water in depressions and short segments of small alluvial channels. The habitat evaluation included wetland delineation of these areas using United States Army Corps of Engineers (USACE) methods. USACE recognizes a feature as a wetland if the area is inundated or saturated by surface or groundwater at a frequency to support, and that under normal circumstances contains, a prevalence of vegetation typically adapted for life in saturated soil conditions (USACE 1987).

Prior to field activities, SulTRAC checked the National Wetland Inventory (NWI) database to identify potential wetlands at OU2 (USFWS 2007). The NWI database identifies two potential bottom forest wetlands within the LVR floodplain. On-site, SulTRAC observed a mixture of upland and bottomland or water-tolerant plants within a narrow floodplain. The woody species SulTRAC noted within the

floodplain were: 1) predominately an oak-hickory community with smaller numbers of American elm (*Ulmus americana*), big-tooth aspen (*Populus grandidentata*), and catalpa (*Catalpa speciosa*); and 2) black willow (*Salix nigra*) and box elder (*Acer negundo*) near the stream channel. The understory consisted of nettle (*Urtica dioica*), poison ivy (*Rhus toxicodendron*), sunflowers (*Helianthus sp.*), and wild parsley (*Lomatium foeniculac*). SulTRAC observed wetland hydrology indicators throughout the narrow floodplain from recent high-flow events. However, SulTRAC classified the soil as a clay loam with the color 10 YR 3/1 (Kollmorgen Instruments Corporation 2000) and did not observe wetland soil indicators. Therefore, SulTRAC concluded that the area is not a jurisdictional wetland.

While examining the floodplain, SulTRAC also observed LVR features. The river is fairly well confined within a steep, narrow valley formed by glacial meltwater and stream erosion. Both banks are composed of a mature wooded riparian corridor except for slag deposits along the southern end of OU2. SulTRAC observed silty shale and limestone outcrops along the valley slope, with small seeps. The only overland drainage features SulTRAC observed connecting to the river were the ASO from previous Matthiessen and Hegeler Zinc Company Site operations and a storm water outfall that discharges only during runoff events. The river itself has riffle/pool sequences throughout OU2. Riffles are predominately a mixture of gravels and cobbles and typically 1 to 2 ft deep at low flow. SulTRAC did not survey pool depths, but pool bottoms were visible in some areas and appeared to be 3 to 5 ft deep. The channel geomorphology appeared stable, with no serious instabilities in the channel banks and bed. The one exception is the slag pile next to the river. This pile rises about 40 ft above the river, where there are steep banks and little vegetation, creating high erosion potential.

Outside the river valley, SulTRAC investigated a small depressional water feature. This small depression apparently received overland drainage from nearby areas, and SulTRAC did not identify an outlet of any kind. The depression contained a variety of plants that favor wet conditions. Dominant species observed were cattails (*Typha angustifolia*), Olney's bulrush (*Scirpus americanus*), and sedges (*Carex sp.*). Along the depression fringe, Kentucky bluegrass (*Poa pratensis*) and Illinois bundle flower (*Desmanthus illioensis*) were predominant. SulTRAC attempted to collect a soil sample to examine, but the soil probe hit refusal just below the ground surface. Therefore, soil conditions do not meet hydric criteria. Upon further examination, SulTRAC discovered a thin layer of organic material over slag and building debris. It appears that land disturbances have changed the topography, creating (in this case) a small depression feature that could not be considered a jurisdictional wetland.

SulTRAC also investigated the abandoned sulfuric acid tanks. The in-ground tanks still had their original brick linings and held water. Around the tank perimeters, SulTRAC observed common reed (*Phragmites*

australis) growing in the shallow water. From the fringe, a quickly-rising slope was held together by the original brickwork. The layers of brick have deteriorated from exposure and rooting action. Around the outer perimeter of each tank, black locust (*Robinia pseudoacacia*), American elm, and cottonwood (*Populus deltoides*) were predominant, with numerous poison ivy vines. The woody vegetation appears similar in age. Like the previous location, SulTRAC found that soils were extremely shallow or nonexistent, with only a thin organic layer over brick or debris. This area also could not be considered a jurisdictional wetland.

Finally, SulTRAC examined several ephemeral channels that drain the disturbed landscape. All of these channels are located around slag piles and building foundations. SulTRAC observed water in a channel only when it was blocked by a crossing or vegetation. Common reed is the dominant vegetation within the channels and banks. The sediments in these channels consist of eroded slag, building materials, and organic debris. Enough organic debris has accumulated in some areas to support vegetation growth. SulTRAC attempted to collect soil samples to assess hydric soil indicators at multiple sites. However, at most locations, the soil probe hit refusal just below the ground surface because of slag and building rubble. The only soil sample SulTRAC was able to retrieve consisted of loam with a color of 5YR 2.5/2 from the top 4 inches and clay with a color of 2.5 YR 4/4 from 4 to 10 inches bgs. SulTRAC did not find any hydric soil indicators. Therefore, the channels could not be considered jurisdictional wetlands. All channels ended just west of the abandoned railroad spur. SulTRAC did not observe any connections between the ephemeral channels and the LVR. Water does enter the LVR through the original sewer network because SulTRAC observed flow at the outfall. Based on observations made by other SulTRAC personnel during previous site visits, the outfall discharges water year round. SulTRAC could not observe where water enters the sewer system, but it seems likely that water seeping into the ground is captured and drained through the sewer infrastructure.

To summarize water features and wetlands, SulTRAC observed several different water features, but they could not be considered jurisdictional wetlands because hydric soil characteristics were lacking at all locations. Furthermore, none of the soils mapped are classified as hydric soils. Most moist areas are present because the disturbed landscape contains numerous small depressions.

SulTRAC identified the following five different habitat types:

- 1) Disturbed, with little or no vegetation
- 2) Disturbed woodland-grassland
- 3) Savannah

- 4) Oak-hickory woodland
- 5) Riverine

The first habitat type consists of disturbed areas where only bare ground is present. These areas are concentrated around former infrastructure remnants. Commonly, slag piles and building debris are the only features present, with no soil or organic matter to support vegetation. Thus, these areas have little habitat value.

The disturbed woodland-grassland areas show some habitat recovery. Enough soil or organic material exists in these areas to support a mixture of woody and herbaceous species. The woody vegetation is typically young and predominantly consists of black locust, American elm, catalpa, big-tooth aspen, smooth sumac (*Rhus glabra*), and Japanese honeysuckle (*Lonicera japonica*). Herbaceous vegetation mainly consists of big bluestem (*Andropogon gerardii*), tall goldenrod (*Solidago altissima*), and Kentucky bluegrass. Toward the northern boundary of OU2, the disturbed wooded area thickens and transitions into a more mature woodland. The woody species are similar, but the understory predominately consists of white snakeroot (*Ageratina altissima*).

The savannah areas have also formed on fairly disturbed ground located on topographic high points. These areas typically contain big bluestem, tall goldenrod, Illinois bundleflower (*Desmanthus illinoensis*), switchgrass (*Panicum virgatum*), and Canada wildrye (*Elymus canadensis*). Mature cottonwoods and smooth sumac are located along the savannah fringe as well as black locust and big-tooth aspen saplings.

The mature oak-hickory woodlands habitat is located along the LVR valley slope and floodplain. The dominant species are burr oak (*Quercus macrocarpa*), white oak (*Quercus alba*), black oak (*Quercus velutina*), red oak (*Quercus rubra*), shingle oak (*Quercus imbricaria*), chinkapin oak (*Quercus muhlenbergii*), and bitternut hickory (*Carya cordiformis*). Also present in lesser quantities are American elm, big-tooth aspen, catalpa, and sugar maple (*Acer saccharum*). Close to LVR, SulTRAC observed box elder and black willow. Within the woodland, SulTRAC found several small areas where water is seeping out of bedrock outcrops. Unidentified mosses and reed canarygrass (*Phalaris arundinacea*) were observed in this area. Overall, these areas had good vegetative composition and age diversity, creating good terrestrial habitat conditions.

The riverine habitat associated with the LVR is diversified by the riffle/pool sequences and should provide good habitat for a variety of fish, macroinvertebrates, and mussel species. The substrate appeared diverse, with silts, gravels, cobbles, and some boulders. Large woody debris was also observed scattered

about the stream. These features also provide good habitat and refuge for aquatic species. The State of Illinois characterizes the LVR as a fishery with smallmouth bass (*Micropterus dolomieu*), bluegill (*Lepomis macrochirus*), sunfish (*Lepomis sp.*), crappie (*Pomoxis sp.*), channel catfish (*Ictalurus punctatus*), bullhead (*Ictalurus sp.*), carp (*Cyprinus carpio*), and drum (*Aplodinotus grunniens*) fish populations (US EPA 2003b).

SulTRAC also documented wildlife species observations during the habitat evaluation, including direct visual species observations or other species evidence such as tracks or scat. SulTRAC observed mammals, including the white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), and coyote (*Canis latrans*). SulTRAC observed and heard several birds but could not identify each species. Birds that SulTRAC did identify included the red-tailed hawk (*Buteo jamaicensis*), turkey vulture (*Cathartes aura*), and cedar waxwing (*Bombycilla cedrorum*). On October 22, 2007, SulTRAC also observed a large winter flock of blackbirds, grackles, and starlings at OU2.

SulTRAC observed several aquatic species in the LVR. SulTRAC found two species of live mussels on one riffle but was not able to identify the genus or species because SulTRAC could not locate remnant shells for classification. SulTRAC also observed several benthic macroinvertebrates species, including mayflies and caddisflies, but SulTRAC did not identify the genus or species.

2.2.7.2 Phase II Ecological Receptor Investigation

The purpose of the Phase II ecological receptor investigation was to assess potential impacts to terrestrial receptors. This assessment included the development of a FCM to estimate the receptors' potential exposures to contaminants. The receptors include primary consumers, omnivores, and carnivores. The FCM focused on mammalian and avian receptors. On August 25 and 26, 2008, SulTRAC personnel conducted field investigations as part of the Phase II RI to collect site-specific information needed to properly characterize the migration of some contaminants from soil up the food chain. To make the FCM more site-specific, SulTRAC collected information on the uptake of soil-bound chemicals of potential ecological concern (COPEC) into vegetation, a significant food source for a number of site-specific receptors. This information will be used to more accurately characterize the potential exposure of receptors in the FCM. SulTRAC used two methods to collect these data: 1) collection of site soil and vegetation samples from areas with a range of known soil contamination levels; and 2) laboratory soil bioaccumulation tests using earthworms (Table 2.2.1-1).

Soil samples were collected from several locations within each habitat of concern and sent to the laboratory for 28-day bioaccumulation tests using earthworms (Figure 2.2.7-1). SulTRAC also identified locations at OU2 with elevated levels of contamination and collected native herbaceous vegetation samples from these locations; the relevant part(s) of the browse were sampled. Each plant collected was divided into two separate portions, an aboveground and underground portion, and each portion was analyzed separately to measure COPEC concentrations in the roots and leafy parts of the plant. This information will allow an understanding of: 1) the bioaccumulation of COPECs in the soils and their potential to migrate within the food chain; and 2) food source contamination.

On August 10 and 11, 2009, SulTRAC collected ecological soil samples at OU2 for lettuce seed germination bioassays to evaluate soil phytotoxicity. The ecological soil sampling field work to evaluate soil phytotoxicity was based on activities described during verbal discussions with and comments received from US EPA in July 2009, and the field procedures were based on activities described in the US EPA approved OU2 Phase II FSP prepared by SulTRAC. SulTRAC collected 10 discrete grab soil samples and one duplicate sample from OU2. All soil samples were collected from several locations within each habitat of concern at the Site. All soil samples were collected from 0 to 6 inches bgs using a stainless-steel shovel. All vegetation was removed from the soil surface before sample collection. The stainless-steel shovel was decontaminated between each sampling location using Alconox® and deionized water. Two equal samples of approximately 2.5 quarts of soil were collected from each sampling location, and the samples were homogenized at the laboratory before initiation of the tests. The minimum final volume of soil was approximately 1 gallon. The soil was stored at 4° C and shipped to the laboratory, TestAmerica, for a 7-day lettuce seed germination test and a 21-day lettuce root and shoot elongation test. Laboratory procedures were conducted in accordance with American Society for Testing and Materials International (ASTM) Standard E 1963-02, "Guide for Conducting Terrestrial Plant Toxicity Tests." The OU2 sampling locations were approximately the same as soil sampling locations for the previously conducted earthworm bioavailability tests and as vegetative sampling locations for the previously conducted vegetation bioavailability tests (Figure 2.2.7-1).

2.2.8 Air Sampling Investigation

Analytical soil sample results from Phase I sampling activities indicated several on-site areas at OU2 where asbestos was detected in surface soil, warranting air sampling at the Matthiessen and Hegeler Zinc Company Site. Passive air sampling and ABS were conducted during Phase II activities at OU2 to better assess exposure and risks associated with asbestos inhalation at the Matthiessen and Hegeler Zinc Company Site. All field air investigation procedures followed the Phase II SAP (SulTRAC 2008b) and

the Phase II SAP Addendum #1, “Activity Based Sampling for Asbestos in Surface Soils – Revision 1” (SulTRAC 2009b).

SulTRAC collected four passive ambient air samples (AsbAir1 through AsbAir4) at OU2 on July 9, 2008, prior to conducting any additional intrusive sampling activities (such as installation of soil borings). Two samples were collected inside the Rolling Mill building, and two samples were collected from the former main industrial area (Figure 2.2.8-1). High-volume Eberline sampling pumps powered by a gas generator were used to collect air samples from the former main industrial area, and low-volume Gillian pumps were used to collect air samples from inside the former Rolling Mill building. SulTRAC calibrated each pump before sampling in accordance with SOP 064 (Appendix S-2). A 25-mm-diameter, three-piece cassette loaded with a mixed cellulose ester (MCE) filter with a pore size of 0.45 μm backed by a 5- μm pore size MCE filter was used for collecting all four air samples. Table 2.2.8-1 summarizes the flow rates, pump start and stop times, and sample volumes for the samples. The four passive air samples were submitted to STAT Laboratories in Chicago, Illinois, for asbestos analysis by transmission electron microscopy (TEM) using National Institute for Occupational Safety and Health (NIOSH) Method 7400.

Additional ABS air sampling using a raking scenario was performed at OU2 on September 30, 2009. In addition to the ABS, US EPA decided to use its experimental automated Releasable Asbestos Field Sampler (RAFS) unit to collect asbestos air samples in conjunction with the ABS. The RAFS unit mimics a raking motion and is positioned on the ground with air filters positioned above the moveable raking components. ABS was conducted by samplers raking the soil with filters attached to their breathing zone areas. The RAFS unit allows collection of repeatable and representative aerosolized asbestos samples from soil. US EPA operated the RAFS unit using the procedures discussed in its site-specific sampling plan (RTI 2009). US EPA further decided to use the RAFS unit in conjunction with ABS because the RAFS aerosolizes asbestos fibers in a small enclosed area, minimizing the spread of asbestos fibers from surface soil. Additionally, if the analytical detection limits for the RAFS and ABS analytical results were similar, these field techniques would be comparable. The RAFS analytical results can also be modeled to calculate inhalation concentrations for human receptors, which is particularly appropriate for the HHRA. RAFS data and results are discussed in the HHRA (Appendix RA). Furthermore, an additional benefit included the time it takes to collect air samples using the RAFS unit was minimal, reducing the labor and funding needed for sampling activities.

Air samples were collected from outdoor locations where analytical results showed approximately one percent of asbestos fibers in surface soil samples collected during Phase I surface soil sampling activities. Sampling locations were limited to areas of known asbestos soil contamination near the one percent

concentration threshold in accordance with the US EPA asbestos guidance (US EPA 2008c). Areas with asbestos concentrations much greater than the one percent threshold where human exposure risks are expected and assumed to be highest were not proposed for ABS or RAFS sampling as these areas are not in contention in terms of human risk. Two locations were chosen to collect air samples using ABS, and four locations were selected for sampling using the RAFS unit (Figure 2.2.8-1). SulTRAC performed the ABS sampling, and US EPA operated the RAFS unit.

SulTRAC conducted ABS for asbestos air sampling as outlined in the US EPA document titled “Framework for Investigating Asbestos-Contaminated Superfund Sites” (US EPA 2008c). The methods stated in this US EPA guidance document provide the most conservative asbestos air sampling results for use in HHRAs (US EPA 2008c). SulTRAC used the sampling procedures discussed in the US EPA Environmental Response Team’s SOP entitled “Activity-Based Air Sampling for Asbestos” dated May 10, 2007 (Appendix S-2).

On September 30, 2009, SulTRAC performed ABS west of Building 100 (AbsAir6) and west of the deep Pump House (AbsAir8). The generic ABS scenario (raking) described in the US EPA Environmental Response Team’s SOP (Appendix S-2) was followed in order to evaluate asbestos fiber releases from the soil. The air samples were collected using personal air sampling equipment to reflect the concentrations of asbestos in the breathing zone. The breathing zone was defined as a hemisphere approximately 6 to 9 inches around an individual’s face (US EPA 2008c). A total of four field samples (two samples from each location) were collected and submitted to the laboratory for asbestos analysis using the ABS raking scenario.

The RAFS unit was used at all four sampling locations (AbsAir5 through AbsAir8) (Figure 2.2.8-1). Asbestos air samples were collected using the RAFS unit first before ABS at locations AbsAir6 and AbsAir8 because the RAFS method does not disturb soil as much as the ABS method.

Concurrent with the ABS raking and RAFS sampling activities, one background and three air perimeter samples were collected (Table 2.2.8-1). The background sample was collected from the LaSalle Fire Department approximately 0.5 mile south of the southernmost boundary of OU2. Originally, perimeter samples were to be collected along the Site boundary at one upwind and three downwind locations. The generator used to power the pumps for ABS malfunctioned. Therefore, upwind perimeter air sampling was terminated. Additionally, a weather station was set up to monitor real-time meteorological conditions such as wind speed and direction.

Before ABS air sample collection, a three-sided, 8- to 10-ft-high plastic screen was erected downwind approximately 20 ft from the sampling locations to suppress any migrating dust. During ABS, the rake width was approximately 20 to 28 inches, and the sampler used the rake to disturb the top 3 inches of soil in an area measuring 5 by 5 ft. The sampling area was raked from left to right and toward the sampler for approximately 15 minutes. The sampler then turned 90 degrees clockwise and began raking a new side in the 5- by 5-ft area for 15 minutes. This pattern was repeated for each side of the 5- by 5-ft-square sampling area. This cycle of raking and rotating continued for approximately 100 minutes.

The sampler was equipped with two SKC Quick Take 30 sampling pumps at each location. One pump was set up for low-volume sampling, and the other pump was set up for high-volume sampling. Table 2.2.8-1 summarizes the flow rates, pump start and stop times, and volumes of the samples collected. The air samples were collected using a 25-mm-diameter, MCE filter cassette with a 0.8- μ m pore size. The sampling cassettes were oriented in the breathing zone with the open face pointing down to prevent any large, non-respirable particles from falling or settling onto the filter media. The personal sampling pumps were calibrated at the beginning and end of each sampling event, and calibration results were recorded in the field logbook. All asbestos air sampling was conducted in the appropriate PPE (Level C), and samplers were rotated every 30 minutes in accordance with health and safety precautions. When samplers were relieved, the switch was conducted in less than 60 seconds. Therefore, the pumps were left running during the switch. A gas generator powered the personal sampling pumps.

QC samples for the ABS event were collected as described in the US EPA Environmental Response Team's SOP (Appendix S-2). QC samples, including one field blank and one lot blank, were collected on the same day of sampling.

RAFS unit sampling was conducted at all four sampling locations (AbsAir5 through AbsAir8). At each sampling location, the RAFS unit was placed at three distinct points to collect air samples. At each point, the RAFS unit collected three separate asbestos and metals air samples. Two 25-mm-diameter MCE filter cassettes and one 25-mm-diameter Teflo filter in polypropylene, closed filter cassettes were used to collect the asbestos air samples. Three separate 25-mm-diameter Teflo filters in polypropylene, open-face filter cassettes were used to collect metals air samples. The flow rate was set at approximately 13.5 liters per minute for approximately 45 to 60 minutes.

In addition to the air samples, US EPA collected composite soil samples at each of the three points within each of the four sampling locations. At each point, a five-point composite sample was collected. The five points of the composite sample included the location of the RAFS raking and four sides (north, south,

east, and west) within 12 inches of the RAFS raking location. At each RAFS unit sampling location, 2 liters of soil was collected for analysis for asbestos and total metals (zinc, lead, arsenic, and mercury).

All samples collected during the ABS and RAFS unit events were submitted to a subcontracted laboratory capable of analyzing the samples in accordance with the International Organization for Standardization (ISO) Method 10312, "Ambient air – Determination of asbestos fibers – Direct-transfer TEM." ICP/mass spectrometry US EPA Method 200.8 was used to analyze the soil and air samples for zinc, lead, arsenic, and mercury.

2.3 SITE-WIDE BACKGROUND SOIL INVESTIGATIONS

During the Phase II sampling activities, site-wide background soil samples were collected for comparison with both OU1 and OU2 sample results to establish the background soil concentrations for total metals and SVOCs in the LaSalle/Peru area. Two background investigations were conducted in December 2009 and December 2010 and are described below.

SulTRAC advanced 18 background soil borings on December 3 and 21, 2009, to collect surface and subsurface soil samples from two depth intervals per boring (Figure 2.3-1). Sixteen soil borings were advanced at five public parks in LaSalle and Peru. Two additional soil borings were advanced on the Peru Fire Department property. Before sampling activities began, public utility clearance was conducted. All soil borings were advanced using hydraulically driven, direct-push technology to collect soil samples from specific depths (see SOP 054, Appendix S-2). Surface soil samples were collected from each boring from 0 to 2 ft bgs, and subsurface soil samples were collected from 8 to 10 ft bgs or the 2-ft interval above the water table. A field geologist logged all soil borings using the SulTRAC geologic logging forms (Appendix S-1). All logging information, sampling procedures, and decontamination procedures were conducted in the same manner used during the Phase I soil investigation ([Section 2.2.1.1](#)).

A total of 36 soil samples were submitted to the CLP laboratory for analysis for total metals, cyanide, and SVOCs. Samples were analyzed using appropriate US EPA methods as listed in Table 2.2.1-3. QC (field duplicate and MS/MSD samples) and other sampling procedures were conducted in accordance with SulTRAC's Phase II SAP (SulTRAC 2008b).

The second background sampling event was conducted on December 6 and 7, 2010. The sampling event was conducted in response to IEPA comments on the draft risk assessment regarding the initial background data set (US EPA 2010a). IEPA's primary concerns were 1) the nearness of initial background sampling locations to the Matthiessen and Hegeler Zinc Company Site and the possibility

that the Site impacted the initial background sampling locations and 2) the collection of soil samples from the shallow interval of 0 to 2 feet bgs instead of from IEPA's preferred surface soil interval of 0 to 6 inches bgs. To address IEPA's concerns, additional background samples were collected in December 2010 to augment the background soil sample data set obtained in December 2009.

On December 6 and 7, 2010, SulTRAC advanced 12 background soil borings to collect surface and subsurface soil samples from two depth intervals per boring (Figure 2.3-1). The 12 soil borings were advanced in five public areas in Ottawa, Spring Valley, and Mendota. Before sampling activities began, public utility clearance was conducted. All soil borings were advanced using hydraulically driven, direct-push technology to collect soil samples from specific depths (see SOP 054, Appendix S-2). In response to IEPA comments, surface soil samples were collected from each boring from 0 to 6 inches bgs and subsurface soil samples were collected from a 2-foot interval between 6 inches to 10 feet bgs. A field geologist logged all soil borings using the SulTRAC geologic logging forms (Appendix S-1). All logging information, sampling procedures, and decontamination procedures were conducted in the same manner used during the 2009 background sampling event described above.

A total of 24 soil samples plus associated QC samples were submitted to the CLP laboratory for analysis for total metals and SVOCs. Samples were analyzed using appropriate US EPA methods as identified in Table 2.2.1-3. QC (field duplicate and MS/MSD samples) and other sampling procedures were conducted in accordance with SulTRAC's Phase II SAP (SulTRAC 2008b).

Appendix RA-2-1 further discusses the December 2010 background data. The background soil sample data are incorporated into the risk assessment (Appendix RA-2-1) and will be used to revise the BTVs in the FS report. The revised BTVs are not included in this RI report.

3.0 PHYSICAL CHARACTERISTICS OF THE SITE

Physical characteristics of the Matthiessen and Hegeler Zinc Company Site affect contaminant distribution and transport, and the exposure of affected populations. This section discusses the general physical setting of the Matthiessen and Hegeler Zinc Company Site ([Section 3.1](#)); physical features of OU1 ([Section 3.2](#)); physical features of OU2 ([Section 3.3](#)); and the site-wide interpretations of soils, geology, and hydrogeology ([Section 3.4](#)).

3.1 GENERAL SETTING

This section discusses surface features, subsurface manmade features, surface water hydrology, weather conditions, demography and land use, regional geology, regional hydrogeology, and ecology for the Matthiessen and Hegeler Zinc Company Site.

3.1.1 Surface Features

The entire Matthiessen and Hegeler Zinc Company Site encompasses approximately 227 acres that include inactive primary zinc smelting and sulfuric acid operations with associated abandoned buildings and tanks, a Rolling Mill, the active Carus facility and its property, the 17.7-acre upland Slag Pile, and the LVR (Figure 1.2.1-1). The Matthiessen and Hegeler Zinc Company Site is bounded by the LVR to the east, industrial properties to the north, and residential properties to the south and west. Topographically, the Matthiessen and Hegeler Zinc Company Site spans approximately 160 ft in elevational difference. The low point is the LVR at 456 ft above mean sea level (msl), in the south eastern portion of the Site. The high point is 613 ft above msl located in the northern portion of OU2, which is just southeast of the off-site rectangular building (Apollo Works) located in the very northwest corner of Figure 1.2.1-1.

Woodlands dominate the north and northeast periphery of the Matthiessen and Hegeler Zinc Company Site. Specifically, the northern area is characterized as a disturbed woodland-grassland with some savannah, and the northeastern portion is characterized as oak-hickory woodland.

In the central portion of the Matthiessen and Hegeler Zinc Company Site where previous historical industrial operations occurred, the surface topography is highly disturbed, with little or no vegetation present. This area, referred to as the former main industrial area, comprises most of the OU2 land mass. In this area, over 100 abandoned buildings either have been demolished or have collapsed from disrepair. As a result, this central area is covered with pits at excavated and crumbling building foundations, ASTs, AST foundations, sinter and slag deposits, scattered piles of waste and building debris (clay pipes, sinter,

slag, soils, etc.), twisted metal and wood ties from old rail spurs, abandoned railcars, and in-ground former sulfuric acid tanks. The central area of the Matthiessen and Hegeler Zinc Company Site contains the following standing but deteriorating structures: the Rolling Mill, Building 100, a deep well pump house, shallow pump houses, a river pump house, former furnaces, former brick-lined kilns, a former stone pottery building, and a former oxide plant. Building demolition, waste deposition, and subsequent redistribution of wastes, debris, and native soils have created a rough, unnatural topography. For example, the topography in the former main industrial area ranges from a high of approximately 607 ft above msl near two circular former acid tanks located in the northern portion of the area to a low of 537 ft above msl between the furnaces and the slag pile.

These alterations in the local topography have subsequently altered on-site drainage networks. Using aerial photographs and detailed land surveys, potential water features were investigated in this central area of the Matthiessen and Hegeler Zinc Company Site. Ephemeral channels, pools, and ponds typically form around slag and debris piles and building foundations and usually are present after rain events or when a water depression is blocked by a road crossing or vegetation. Although ephemeral by nature, these channels, pools, and ponds drain the disturbed central area landscape. The substrate for these ephemeral channels, pools, and ponds typically consists of eroded sinter, slag, or fill, building materials, and minor soils or organic debris. However, enough organic debris has accumulated in some areas to support some vegetation growth.

The central area is open, and most of it is topographically higher than the former railroad tracks that extend north to south along the entire east side of the Matthiessen and Hegeler Zinc Company Site. The former ICRR grade ranges in elevation between 556 ft above msl in the northern portion of the Site to 536 ft above msl just west of the slag pile. The surface topography slopes dramatically from the former railroad grade to the LVR to the east. Weathered bedrock shale and limestone outcrops are visible along the forested/vegetated corridor sloping toward the LVR, and small seeps have been observed just west of the slag pile and just south of OU2.

South of this central area is the active Carus facility, which is part of OU1. This area is industrial, with paved or asphalt surfaces, and relatively flat. East of the Carus facility and southeast of the central area of the Site (the OU2 former main industrial area) is a 17.7-acre Slag Pile, also part of OU1, which reaches a maximum height of approximately 560 ft above msl, 80 to 90 ft above the surface of the LVR. A retention pond for the Carus facility is also located within the Slag Pile. The Slag Pile is quite steep and is at or near the angle of repose in many places. The steep high banks and little vegetation on the Slag Pile present high erosion potential.

The eastern and northeastern border of the entire Matthiessen and Hegeler Zinc Company Site is bounded by the LVR and associated floodplain. The LVR is a bedrock river and part of OU1. The LVR floodplains are narrow and contain a mixture of upland and bottomland or water-tolerant plants. The LVR is fairly well confined within a steep, narrow valley formed by glacial melt water and stream erosion. Both banks are composed of a mature wooded riparian corridor except for slag deposits along the southern end of OU2 and along the Slag Pile. The LVR itself has riffle/pool sequences. Riffles are predominately a mixture of gravels and cobbles and typically 1 to 2 ft deep at low flow. Pool bottoms are often visible in many areas alongside the Matthiessen and Hegeler Zinc Company Site and appear to be 3 to 5 ft deep. The channel geomorphology appears stable, with no serious instabilities in the channel banks and bed. The one exception is the 17.7-acre Slag Pile next to the LVR.

3.1.2 Subsurface Manmade Features

Substantial subsurface features are present at multiple depths across the Matthiessen and Hegeler Zinc Company Site. During the 1800s and early 1900s, coal was mined in this portion of Illinois and specifically in LaSalle. Coal was mined to provide an energy source for the former zinc smelters and kilns on the Matthiessen and Hegeler Zinc Company Site. The coal mine is located under the entire Matthiessen and Hegeler Zinc Company Site as well as the Cities of LaSalle and Peru. Three associated mine shafts were also present on OU2. The coal was mined from the Herrin and Colchester Formations (Illinois State Geological Survey [ISGS] 1985).

The Herrin Formation is the shallower of the two formations and located at approximately 225 to 250 ft bgs, while the Colchester Formation is located at approximately 300 to 400 ft bgs (ISGS 2009a and 2009b). It is reported that deep coal mining occurred in the LaSalle-Peru Area along the Illinois River from the late 1800s until around 1915 (ISGS 1985). The Herrin Formation Coal was mined almost exclusively using underground methods, the room-and-pillar method, which appears on mining maps in the Matthiessen and Hegeler Zinc Company Site archival records. However, most coal was mined in the thicker Colchester Formation, usually using the longwall method. Deep coal mining in the LaSalle-Peru Area sharply declined after 1915 as rail access allowed thicker coal deposits from southern Illinois to be more cheaply transported to this area. However, surface mining in the Colchester Formation began in the 1920s because the coal in the formation had a low to moderate sulfur content and was accessible (ISGS 1985). Historical maps of the Site area show three mine shafts, all of which were ground-truthed in 2007 and were never found. The mine shafts presumably were backfilled at some point during the Matthiessen and Hegeler Zinc Company Site history.

Underground structures at OU1, specifically in the Carus facility area and the Slag Pile, include storm and sanitary sewer lines, utility lines, and water lines. Floor troughs and sumps are located inside Carus facility areas. There are no process pipelines outside of buildings. A non-contact cooling water discharge line runs from the Carus facility to the north end of the holding pond near the south end of the Slag Pile. The NPDES permitted discharge pipe extends from the holding pond through an earth berm and discharges to the LVR near the southeast corner of the holding pond. Various floor troughs and sumps are present underground within the Carus facility area. Additionally, utility lines, including gas, oxygen, and water, are located underground within the Carus facility area.

Specific to OU2, manmade subsurface features include an abandoned sewer line and associated manholes (Figure 2.2.5-1), an intake tunnel that historically connected the river pump house on OU2 to a settling pond next to the LVR, and former plant operation tunnels. The underground abandoned sewer line is sealed at the OU2 boundary at Sterling Street, is approximately 2,500 linear ft long, runs west to east across most of OU2, and ultimately empties into the LVR. The abandoned sewer line is constructed of brick and mortar, is located approximately 4 to 8 ft bgs, is 4 to 5 ft high, and is 5 to 6 ft in diameter in an uncollapsed condition. Seven purported manholes provide entry into the abandoned sewer line, of which only two are currently visible at the surface. Manhole #7 is backfilled with fill and debris, and manhole #6 is sealed shut with concrete.

Historical maps of the Matthiessen and Hegeler Zinc Company Site from the early 1900s show that an intake tunnel was present at one time during past operations. This intake tunnel was approximately 650 ft long and connected the river pump house on the eastern portion of OU2 to a settling pond next to the LVR. The river pump house presumably was gravity-fed through this intake tunnel from the settling pond and LVR. Currently, there is no evidence of a settling pond, nor has any water been observed at the base of the river pump house. There is also limited ability to explore the base of the river pump house due to its deteriorated condition.

Historical maps of the Matthiessen and Hegeler Zinc Company Site also show that small tunnels were present during active smelter and furnace operations. During RI field activities, a tunnel was found south of the furnaces and upon inspection had standing water, indicating it is not likely a pathway for surface water or groundwater. There are remnants of tunnels covered or buried across the former main industrial area on OU2.

3.1.3 Surface Water Hydrology

LaSalle County lies within the Illinois River Drainage Basin. The Illinois River flows across the central portion of LaSalle County in a westerly direction. Overall, LaSalle County is moderately well-drained, although marshes occur near the headwaters of some upland creeks. Important tributaries of the Illinois River include the Fox River, the Vermilion River, and the LVR, the latter of which flows from north to south along the eastern property boundary of the Site. The watershed for the LVR covers approximately 125 square miles, or 80,240 acres. The watershed extends from its confluence with the Illinois River more than 20 miles to the north almost to Lee County and extends slightly into Bureau County to the west. There are several small lakes to the south of the Site within the floodplain of the Illinois River, including Split Rock Lake and Huse Lake (Figure 3.1.3-1).

Two man-made surface water bodies are present on OU1, the emergency containment pond, immediately adjacent to the east of the Carus facility at the approximate elevation of the former railroad grade, and the holding pond, to the southeast of the Carus facility near the south end of the Slag Pile. The emergency containment pond does not have a formal outlet and receives non-contact cooling water from the Carus facility on infrequent occasions. When not receiving water from the Carus plant, the emergency containment pond may collect storm water but is frequently dry. The emergency containment pond does have a drain which, when the pond is not in use, is open and allows the pond to drain to the holding pond. The holding pond receives non-contact cooling water from the Carus plant and discharges through an NPDES-permitted discharge into the LVR near the southeastern end of OU1. Both of these basins are on OU1. An emergency storage area is present at the eastern edge of the Carus plant area, but generally holds little water.

Surface water on OU2 is limited to an ephemeral stream in the central portion of the main manufacturing area. This stream does not continue to connect with the LVR, and may either drain or infiltrate into the abandoned sewer system in the subsurface at OU2. Other surface water identified at OU2 was present in concrete structures remaining from the former industrial uses. Additionally, a seep area was identified along the former railroad bed in the border area between OU1 and OU2 near the north end of the Slag Pile, with the seepage likely originating on OU2.

3.1.4 Weather Conditions

The mean monthly temperature in the City of LaSalle varies between approximately 20°F in January to 74°F in July. Mean annual rainfall is approximately 37.7 inches. Monthly temperatures and precipitation

are presented below (National Weather Service, 2009).

Month	Avg. High	Avg. Low	Mean	Average Precipitation
January	29°F	12°F	20°F	1.46 in.
February	35°F	17°F	26°F	1.42 in.
March	47°F	28°F	38°F	2.67 in.
April	61°F	38°F	50°F	3.60 in.
May	73°F	49°F	61°F	4.55 in.
June	82°F	59°F	71°F	4.10 in.
July	85°F	63°F	74°F	4.04 in.
August	83°F	61°F	72°F	4.11 in.
September	77°F	52°F	64°F	3.63 in.
October	65°F	41°F	53°F	3.00 in.
November	48°F	30°F	39°F	2.83 in.
December	35°F	18°F	26°F	2.29 in.

The prevailing wind is from the south with an average velocity of 11 mph.

3.1.5 Demography and Land Use

The area in the vicinity of the Matthiessen and Hegeler Zinc Company Site consists of mixed land uses, including industrial and residential uses. Specifically, residential property and a community park are located near the Site, which is bounded by industrial operations to the north, the LVR to the east, and private residences to the south and west (Figure 1.2.1-1).

According to the 2000 U.S. Census Bureau, the estimated population for the City of LaSalle was 9,796. This population consists of Caucasian, non-Hispanic descent (89 percent); Hispanic descent (8.2 percent); other races (3.1 percent); African-American descent (1.3 percent); and those of two or more races (1.2 percent). The median resident age is 38.1 years (U.S. Census Bureau 2000). In 2007, the estimated median household income in the City of LaSalle was \$38,780, which is less than the State of Illinois median household income of \$54,124. Most of the workforce in the City of LaSalle is employed in unskilled labor categories such as construction (12 percent), metal and metal products manufacturing (10 percent), machinery (5 percent), repair and maintenance (4 percent), and motor vehicle manufacturing and parts dealers (4 percent). The 2008 cost of living index in the City of LaSalle was 77.2, which is below the nationwide average of 100 (City-data 2009).

3.1.6 Regional Geology

The regional geology of north-central Illinois consists of unconsolidated Pleistocene glacial deposits overlying Paleozoic sedimentary deposits. The surficial geology in the Site vicinity is shown on Figure 3.1.6-1, Surficial Geology of LaSalle Quadrangle, LaSalle County, Illinois (Shields et al. 2005).

For the purposes of this investigation, the Paleozoic strata can be divided into lower Paleozoic deposits and upper Paleozoic deposits. The lower Paleozoic deposits consist primarily of sandstone, dolomite, and shale, and are on the order of 4,800 ft thick. The upper Paleozoic deposits, which are Pennsylvanian age, consist primarily of shale, limestone, sandstone, and coal, and are on the order of 400 ft thick. The distinction between lower and upper Paleozoic deposits is significant with respect to the Split Rock Monocline, which is a prominent geological structure in the region.

The Split Rock Monocline (Shields et al. 2005) is a sharp, southwestward-dipping flexure in the lower Paleozoic sedimentary strata. The flexure was formed after deposition of the lower Paleozoic strata but before deposition of the upper Paleozoic strata. The axis of flexure on the northwest to southeast trending monocline is located approximately one mile to the east of the Site. The effect of this flexure is that lower Paleozoic strata that exist at depths of 1,500 ft at an approximate distance of 1.5 miles to the

southwest of the Site are exposed at or near the ground-surface about one mile to the northeast of the Site. However, this sharp flexure does not occur within the upper Paleozoic (Pennsylvanian) strata. The upper Paleozoic deposits overlap and thin against the flexure.

During the Mesozoic and early Cenozoic periods in Illinois, emergence of the Paleozoic formations resulted in widespread erosion and production of a low-relief topography. During the Pleistocene Epoch, glaciers advanced over the region, scouring out softer rocks and soils. As the ice melted, large volumes of rock and soil debris were left behind in the form of glacial drift. Glacial drift deposits range up to 600 ft in thickness in the region.

Glacial-drift thicknesses near the Site were estimated from formation descriptions provided in well construction reports. Within a 5-mile radius of the Site, drift thicknesses range from less than 0 to approximately 100 ft. The average thickness of glacial deposits is approximately 40 ft within an area bounded to the south by the Illinois River and the east by the LVR. South of the Illinois River and west of the Vermilion River glacial deposits average approximately 60 ft thick. Northeast of the Site, across the LVR, glacial deposits appear to be 10 ft thick or less. Pennsylvanian age and older formations outcrop to the east of the LVR, as the crest of the Split Rock Monocline is approached.

3.1.7 Regional Hydrogeology

Aquifers within north-central Illinois are represented by sands and gravels occurring within the glacial drift, alluvial valley fill deposits, and permeable bedrock formations, principally sandstones and dolomites.

A review of vicinity water well logs from the ISGS for wells within a 2-mile radius of the Site showed 82 wells, Figure 3.1.7-1. However, available information for a majority of the wells did not indicate the formation in which the well was completed. Of those records where some information was provided on the formation, 10 indicated the wells were completed in sand and gravel or alluvium, while 21 indicated rock, limestone, shale, or sandstone, which is interpreted as wells completed as bedrock wells. The sand and gravel wells ranged from 31 to 72 ft deep and had pumping rates of from 10 GPM to 1,675 GPM. It was not possible to distinguish from the well logs whether these wells were installed in glacial drift sand and gravel (outwash) deposits, or in stream and river valley alluvial deposits.

The bedrock wells ranged from 31 to 830 ft deep, with the majority in the 100 to 300 ft range, and had pumping rates from 10 to 50 GPM. Those wells that were not designated as to the formation in which they were completed ranged as deep as 2,665 ft, and had pumping rates of as high as 1,580 GPM, with the

higher pumping rates typically from shallow wells less than 100 ft deep.

The City of LaSalle has a well field approximately 0.6 mile south of the Site, within the Illinois River Valley. High capacity production wells are more typically found in the alluvial sand and gravel deposits along major river valleys rather than in bedrock wells. The LaSalle City water supply wells are screened in alluvial sand and gravel at depths ranging from 60 to 70 ft bgs. The City of Peru operates a municipal well field approximately two miles northwest of the Site. Water is obtained from lower Paleozoic bedrock formations at depths greater than 2,000 ft bgs.

The location of the public water supply wells is shown on Figure 3.1.7-1. In the records obtained from the ISGS, twenty-two wells were attributed to the cities of LaSalle (17 wells), Peru (four wells), or Kernan (one well). These wells are either sufficiently distant from the Site as to be outside the likely zone of impact, or are upgradient or cross-gradient from the Site so as to preclude impacts from the Site on these wells.

3.1.8 Ecology

The Matthiessen and Hegeler Zinc Company Site is comprised of 227 acres of current and former industrial property in eastern LaSalle, Illinois and is bordered by residential development to the west and the LVR to the east. The Site consists of terrestrial habitats of varied quality and riverine habitats associated with the LVR.

The LVR system represents “waters of the State” of Illinois and of the U.S., and likely supports riparian “bed and bank” wetlands that would be considered jurisdictional. With the exception of the holding pond at the south end of the Slag Pile, no wetlands were found on the upland portions of the Site (National Wetlands Inventory Maps). Portions of the LVR adjacent to OU2 were also mapped as wetlands. Aside from the LVR, there are two man-made ponds (described in [Section 3.1.2](#)) constructed and operated for the purpose of providing spill prevention and control for CWA compliance associated with the daily operations of the plant. These permitted features are not considered jurisdictional (33 CFR §328.3).

The presence of pollutants notwithstanding, physical alterations of the landscape in the upland portions of Site have resulted in the presence of large areas of sparse and degraded habitat for terrestrial ecological receptors. In the most highly disturbed areas around the former zinc smelter facility infrastructure, the operating Carus plant and the Slag Pile, no soil organic matter is available to support vegetation. Some areas along the periphery of the highly disturbed habitat have enough soil or organic material to support habitat recovery as indicated by the mixture of woody and herbaceous species present in some of these

areas. Pockets of savanna habitat have formed on topographical high points located within the former zinc smelting facility. These degraded areas support no critical habitat for state- or federally-protected species.

Towards the northern boundary of the Site, the disturbed wooded area thickens and transitions into a more mature oak-hickory woodland extending along the LVR valley slope and floodplain. The floodplain areas along the LVR contain mature riparian habitat. Overall, these areas appeared to have relatively good vegetative composition and age diversity, indicating ecologically viable terrestrial habitat conditions.

The riverine habitat associated with the LVR has diversity created by the riffle/pool sequences that should provide sufficient habitat to support a variety of fish, macroinvertebrates, and mussel species. The LVR substrate appeared diverse, with silts, gravels, cobbles, and some boulders, and includes slag materials in various sizes from small gravel to large boulders adjacent to and downstream of the Slag Pile. Large woody debris was also observed scattered about the stream. These features also provide habitat and refuge for aquatic species.

3.2 OU1 FEATURES

The OU1 soils, geology, and hydrogeology are discussed below.

3.2.1 Soils

OU1 is comprised of the operating Carus Chemical plant in the western portion of the Site, and the Slag Pile and LVR in the eastern portion of the Site. Both of these areas are significantly disturbed, and little remains of any natural soil profile. Figure 3.2.1-1 shows the OU1 soils as established by the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS). The soils present on OU1 consist of sinter and slag residue, and silty clay fill soils derived from the glacial till or weathered from the Pennsylvanian bedrock limestone and shale. The silty clay material has been graded to construct the former railroad grade that runs along the western edge of the Slag Pile. The LaSalle County Soil Survey and USDA NRCS classify the soils as Orthents; Appleriver, DuPage, Marseilles, Northfield and Ritchey Silt Loams; and Russ Loam (USDA NRCS 2008).

The areas classified as Orthents loamy, rolling or undulating, are generally well drained, anthropogenic altered soils consisting of a mixture of materials, grain sizes and other urban surfaces. The Plant Area and the majority of the Slag Pile are mapped as Orthents.

The small areas within OU1 that consist of the valley slopes and bluffs not covered by the Slag Pile or other features such as the ponds or railroad grade, are mapped as Marseilles Silt Loam, 10 to 18 percent slopes. These are well drained to moderately well drained soils formed in a thin layer of loess and the underlying residuum from weathered shale. The toe of the Slag Pile is also mapped as Marseilles silt loam, 35 to 60 percent slopes, but this may simply reflect the mapped area of the soils on the bluffs from the east side of the river. A narrow strip of Apppleriver Silt Loam, 0 to 2 percent slopes, is present along the western margin of the Plant Area. Another area of Apppleriver Silt Loam, 2 to 5 percent slopes, is present near the bluff edge south of the Plant Area and west of the holding pond. A small area mapped as a mixture of Marseilles, Northfield and Ritchey Silt Loam, 30 to 60 percent slopes, is shown at the bluff of the river where the 5th Street Bridge crosses the LVR. Additionally, two small areas are mapped as DuPage Silt Loam and Russ Loam, 0 to 2 percent slopes, frequently flooded, within the LVR floodplain near the north and the south ends of OU1, respectively.

The majority of the Plant Area is paved with asphalt or concrete, or covered with buildings. Boring logs indicate the natural formations below the pavement sections are generally within several feet of the pavement surface in the Plant Area, with the fill thickening toward the east, toward the LVR. This facilitates groundwater flow along a sloping top of rock surface toward the east in the Plant Area (Figures 3.2.2-1 through 3.2.2-3, cross sections A'-A'' through D-D').

The Slag Pile itself has little in the way of soil developed beyond decomposed leaf litter where vegetation has become established. Much of the Slag Pile, particularly on the slope above the LVR, is barren of any vegetation or developed soil. Along the banks of the LVR in OU1, the soils are alluvial silt, clay, sand and gravel mixtures with slag mixed in varying proportions. Little soil development has occurred in this area due to the presence of the Slag Pile, and the erosion occurring along the banks of the LVR. The Slag Pile and alluvial soils within the LVR valley are discussed in greater detail in [Section 3.2.2](#), Geology, and [Section 3.2.3](#), Hydrogeology.

3.2.2 Geology

The rock and soil beneath OU1 include both natural and man-made deposits of sediment and fill material. Each type of deposit has chemical and hydrogeologic properties which are unique and individually significant to the flow and chemical composition of the shallow groundwater beneath OU1. For this report, these deposits are divided into the following four general groups on the basis of age and origin:

- Pennsylvanian System, which includes the bedrock and residual soils formed on it

- Pleistocene Series, which includes the glacial deposits beneath the northeastern corner of the Plant Area
- Holocene alluvium, which is evident along the LVR channel and beneath portions of the Slag Pile
- Modern fill, which includes all materials which have been deposited or reworked by human action since the onset of industrial operations

The remainder of this section consists of a systematic description of each of these four groups of materials, including: 1) overall makeup and distribution; 2) internal composition; and 3) a general description of hydrogeologic properties, if applicable.

Pennsylvanian System: The Pennsylvanian System constitutes the bedrock and underlies the entire area around OU1. Within the area of investigation, the Pennsylvanian System consists of horizontal or nearly horizontal layers of shale and limestone with a few thin beds of coal and sandstone. In many areas, a mantle of residual soil has developed within the upper few feet of the Pennsylvanian deposits. The Pennsylvanian System includes the following various rock types, 1) green shale, which includes some coal and gray claystone; 2) red shale; 3) limestone; and 4) gray shale with thin beds of limestone. The Pennsylvanian section is not well exposed on OU1, although the type sections for several members of the McLean Group are exposed on the bluffs on the east side of the LVR opposite the Matthiessen and Hegeler Zinc Company Site (Willman et al. 1975). Additionally, the Pennsylvanian section is not penetrated for any significant length in any of the borings on OU1, although portions of the section over a nearly 150 ft thickness are encountered in different borings. Borings encountering the Pennsylvanian section extend from elevation approximately 573 ft in the Plant Area in borings MW-311R, C-3, G-05, C-9, G-01 on cross section C-C'; and MW-317R, C-13 and G-02 on cross section D-D' down to borings encountering bedrock at elevation 428 ft in SB-309, and 433 ft in P-17 on sections A'-A'' and D-D', Figures 3.2.2-1 through 3.2.2-3.

Limestone bedrock is encountered in the Plant Area as the uppermost bedrock unit (MW-311R, MW-317R, and C-13) on cross sections C-C' and D-D'. Green shale is also evident in the Pennsylvanian bedrock in the Plant Area in borings C-3 and G-05 on cross section C-C'. Red shale is intermixed with green shale in borings C-9 and G-01 deeper in the Pennsylvanian section. The bedrock beneath the Slag Pile in OU1 down slope from the Plant Area is encountered on relatively few borings, but appears to be a reddish brown shale in borings MW-306S and SB-320H in sections A'-A'' and B-B' respectively. Beneath the alluvium, in the lowermost sections of Pennsylvanian bedrock encountered on OU1, the strata include weathered green shale (P-17), limestone bedrock (SB-309), and green shale (P-15).

A relatively thin, but highly fractured coal bed was noted in boring G-02. The strata above and below that horizon were described as dry, although the boring log describes water in the borehole upon penetrating the coal. This suggests the coal is much more transmissive than the shale and limestone material above and below that horizon.

Pleistocene Deposits: The Pleistocene Series is represented by the Lemont Formation glacial till deposits. Within OU1, this unit is generally confined to the upland areas under the Carus plant. The till is present as an approximately 10-ft thick section in the northwest part of OU1 (MW-311R), is thinner beneath much of the Plant Area, and thickens in G-101, G-103 and P-6 near the northeast corner of the Plant Area, where it is up to approximately 20 ft thick. The till is comprised of several different lithologies: 1) coarse till; 2) fine till; and 3) silty clay.

Holocene Alluvium: Alluvial deposits appear to be confined to the valley of the LVR, and consist mainly of loose sandy gravel, silty sand and sandy silt. The depth of the alluvial deposits is unknown. The alluvial deposits are believed to be of Holocene age (within the past 10,000 years), but a Pleistocene component may also be present. In the section of the river that flows by OU1, portions of the alluvial deposits have been buried by deposits of slag.

Figures 3.2.2-1 through 3.2.2-3 show the alluvial deposits mixed with slag beneath the Slag Pile. At greater depths, the alluvium is present with no admixture of slag. In Boring P-17, which encounters weathered green shale bedrock beneath the alluvial deposits, the alluvium extends to a depth of 20 ft beneath the base of the slag. However, it is not clear that this boring penetrates the thickest section of the alluvial valley fill deposits.

Fill Deposits: Fill deposits were observed to cover large areas of OU1. Significant deposits were found mainly in the central part of the Plant Area where they constitute the infill material for a former erosional gully, described more fully in [Section 3.2.3.1](#). The fill deposits are both complex and significant to the flow and potentially to the quality of groundwater. In general, the following types of fill were observed during this site investigation: 1) soil fill; 2) sinter; and 3) slag.

Soil Fill - Soil fill consists primarily of reworked Pennsylvanian shale and glacial till. In general, the reworked shale and till appear to have been derived from residual soil developed in the top of the calcareous green shale, as well as from unweathered shale and siltstone. The reworked shale is characterized by a loosely compacted jumble of shale and siltstone clods with a small amount of miscellaneous fill material. In addition to the reworked shale, the following other types of fill soils were

investigated: 1) sediment from the OU1 pond that lies beneath the reworked shale in Borings G-05, C-3, and possibly C-10; 2) structural fill associated with the ICRR grade; 3) miscellaneous shallow fill and road gravel; and 4) the compacted clay liner constructed for the emergency storage area.

Sinter Fill - Sinter, in the context of zinc production, is an intermediate product consisting of agglomerated zinc oxide. Sinter is produced when zinc sulfide ore is roasted, which causes the sulfur to be driven off and the zinc to oxidize. The sinter investigated in the fill deposits is presumed to have been off-specification material. Where encountered in the borings, the sinter consisted of black, loose granular material, the size of medium sand.

Slag Fill - Slag is the recrystallized or vitrified silicate and oxide residue from the production of metal from ore. Typically, and as observed at OU1, slag ranges in color from moderate red to blackish red and has a highly porous, cindery, vesicular texture similar to scoriaceous lava rock. Much of the slag appears to have become welded into large blocks by its own heat prior to and during deposition. Slag deposits observed in outcrops of OU1 were extremely porous with large, interconnected voids on the order of 0.3 to 1.0 ft across.

3.2.3 Hydrogeology

The hydrogeology of OU1 varies across the different geographic parts of the Site. The three principal geographic areas which comprise OU1 are the Plant Area, the bluff slopes, and the LVR valley. Within these areas there are several hydrogeologic units comprised of the geologic units described above. As noted above, the Pennsylvanian bedrock underlies the entire area at varying depths. The glacial till is present in relatively isolated areas, mainly in the Plant Area, and overlies the bedrock where present. The alluvial soils are limited to the LVR valley, and as with the till lie directly on the Pennsylvanian bedrock. The fill soils, both the reworked soil and sinter and slag materials, are generally present on the bluff slopes where they form the Slag Pile, occupy the railroad grade, and also underlie portions of the Plant Area. The Slag Pile also overlies portions of the alluvial deposits where they encroach on the former LVR valley.

Two WBZs have been identified at the Matthiessen and Hegeler Zinc Company Site. Water-bearing zone 1 (WBZ1) consists of the unconsolidated units and includes the glacial till, alluvial sediments, reworked fill soils, and slag and debris deposits. Water-bearing zone 2 (WBZ2) consists of the Pennsylvanian bedrock comprised of the weathered upper mantle and the more intact bedrock shale, limestone and coal units.

The subsurface geologic units are shown on the geologic cross sections on Figures 3.2.2-1 through 3.2.2-3.

3.2.3.1 Hydrogeologic Characteristics

Table 3.2.3-1 presents a summary of the hydraulic conductivity testing for the wells on OU1. The hydrogeologic interpretations and associated figures for OU2 are presented in [Section 3.3.3](#). The Pennsylvanian bedrock generally exhibits low hydrologic conductivity or permeability. The shale strata are likely lower permeability than the limestone or coal beds, and generally will control the overall permeability of this unit. Slug tests in four Pennsylvanian bedrock wells measured hydraulic conductivity in the range of 4.0×10^{-6} to 5.0×10^{-4} centimeter per second (cm/sec), likely reflecting the difference between relatively intact shale and fractured and weathered top of bedrock. The weathered and fractured upper portions of the bedrock are likely more permeable than the intact rock, with the intact lower permeability bedrock acting as a base to the water table hydrogeologic system which is the uppermost WBZ at the Site. Deeper, more intact portions of the Pennsylvanian system are judged to provide an effective isolation of the surface groundwater system from deeper water supply aquifers.

A former erosional gully beneath the eastern part of the Plant Area was filled with slag and soil, and influences the groundwater in this part of OU1, Figure 3.2.3-1. Groundwater will generally drain toward this filled gully along the top of the lower permeability bedrock surface, eventually draining to the bluff face beneath the surface of the Slag Pile.

The glacial till is apparently of limited extent, with mapped units noted only in eastern portions of the Plant Area. The till ranges from relatively fine-grained, silt and clay to coarser material with abundant sand and gravel. The slug tests conducted in two wells completed in glacial till were 1.6×10^{-4} and 2.7×10^{-3} cm/sec. The higher permeability material was described as coarse till.

The alluvial soils encountered in borings that extended through the Slag Pile consisted of silt, sand and gravel formerly in the LVR stream channel. Those materials are likely mixed to some extent with the slag that was deposited over the alluvial deposits and hydraulic conductivity measurements may reflect the character of this mixture. The hydraulic conductivity of the alluvial soils was measured through pump tests in two wells; the measured hydraulic conductivities were 5×10^{-3} and 7×10^{-3} cm/sec.

The hydraulic conductivity of the slag was measured through both pump tests and slug tests in two separate wells. Slug tests were not conducted in additional wells, as the wells did not have sufficient water to conduct the tests. The results were in relatively close agreement between the two test methods,

and between the two wells tested. The data indicate relatively high hydraulic conductivity ranging from a low of approximately 4×10^{-2} to a high of 2×10^{-1} cm/sec. The fill soil was also assessed in one slug test. That slug test measured hydraulic conductivity of 2.0×10^{-3} cm/sec. That material likely consists of reworked till and weathered bedrock. The testing suggests the soil fill materials has generally higher permeability than the weathered bedrock and is similar to the coarser glacial till materials.

These hydraulic conductivity data indicate there are no significant widely distributed low permeability horizons above the bedrock surface. This absence of aquitards suggests the two WBZs beneath OU1 may be acting as a single interconnected system. The differences in hydraulic conductivity will influence the ease with which water can move in these materials; however, there does not appear to be an effective horizon to isolate one unit from other units. That is to say the water in the upper weathered and fractured Pennsylvanian bedrock is not isolated from groundwater in the glacial till. These two units are not isolated from the soil fill and sinter and slag fill along the bluffs of the valley. Additionally, the bedrock and slag fill are in hydraulic contact with the alluvial valley fill deposits.

3.2.3.2 Variations in Water Levels

Water levels in wells and piezometers at OU1 have been measured at varying frequencies since 1991. From November 2007 through October 2009, water levels were measured quarterly, generally in coordination with measurements in OU2. The water levels from representative surveys of WBZ1 and WBZ2 in September 2008 are shown in Figures 3.2.3-2 and 3.2.3-3, respectively. The water levels from representative surveys of WBZ1 and WBZ2 in March 2009 for OU1 are shown in Figures 3.2.3-4 and 3.2.3-5, respectively. The historical groundwater level data are presented in Appendix G-3-1.

Historical water levels from 1993 show a groundwater mound evident in several borings and wells in the Plant Area, Figure 3.2.3-6. Subsequently, it was hypothesized that a storm sewer was leaking in this area and likely recharging the groundwater. Some repairs were made to sewer lines throughout the Plant Area as well as continuing maintenance of sewer lines, and subsequent water level monitoring has not detected a groundwater mound beneath the Plant Area.

The wells in the Plant Area do not exhibit significant, consistent seasonal variation. Review of the water levels from the Plant Area show some wells rising while others are dropping. This inconsistent variation is likely the result of the majority of the plant being paved, with little infiltration to impact the water levels in the soil. Water level changes of greater than 1 ft are evident in numerous wells between sampling rounds, but there does not appear to be a consistent seasonal variation. The range in water

levels may be the result of differences in local precipitation events, or other influences such as the repair of drainage pipes, pavement placement or repairs, or other man-made influences. These variations are evident in both bedrock wells and glacial till wells in the Plant Area.

Similarly, the glacial till soils show some inconsistent variation in the range of several feet. The water perched in the till is also likely perched on top of the lower permeability intact shale bedrock.

Within the fill soils, seasonal variation in the slag wells is evident by a number of the wells being dry during portions of the year. The relatively free draining nature of the slag is judged to be the reason that no water levels can be measured for significant portions of the year, as the water drains to the base of the slag and top of bedrock interface, and flows down the buried bluff slope toward the LVR.

Water levels in wells installed in the alluvial soils show some variability. MW301-H has shown rising water levels since the well was installed in late 2007. The three alluvial wells all showed their lowest levels in late 2007 and 2008, likely as a result of regional drought conditions. In MW-303H and MW-305H, the highest levels were measured in September 2008, following heavy precipitation events in the late summer. The lowest levels in those wells recently have generally been in the summer.

Two interstitial water sampling points were installed at the toe of the Slag Pile adjacent to the LVR June 2009. Water levels were measured in the wells and in the adjacent LVR at each sampling event, so as to assess the gradient between the wells and the LVR at the time of sampling. Table 3.2.3-2 shows the water levels in the sampling points and in the LVR at three sampling events and/or water level measuring surveys. These data indicate that the localized gradient within the immediate riverbank can exhibit either discharge (from the bank into the LVR) or recharge (from the LVR into the bank. The range in stage that the LVR experiences can be substantial, with water level rising on the order of 5 to 6 ft or more within several days of heavy precipitation events within the LVR watershed. This suggests that there can be a significant recharge of the groundwater from the river into the bank. These events are not likely to be captured in the data collected as part of the water level surveys at the Site, as these interstitial water sampling points are likely under water during the flood events.

3.2.3.3 Groundwater Gradients, Recharge and Discharge

The groundwater gradients evident in the OU1 wells installed in WBZ2 in the Pennsylvanian bedrock exhibit a gradient generally toward the east (Figures 3.2.3-3 and 3.2.3-4). This gradient is likely a combination of the slope of the bedding in the bedrock to the east, and the groundwater flow trending toward discharge in the LVR valley. The gradient within the Plant Area is relatively flat, and shows a

groundwater divide with gradients trending to the east and west from the middle of the Plant Area. While data are limited, gradients in wells in the Plant Area are on the order of 0.01 foot per foot (ft/ft) toward the west to 0.02 ft/ft toward the east. In that the gradients are relatively flat and variable in this area, the actual flow of groundwater in WBZ2 is likely quite limited, due to the relatively low hydraulic conductivity of the bedrock, limited to the weathered and fractured uppermost bedrock surface, and the fact that much of the Plant Area is paved, restricting infiltration of surface water and recharge to the shallow groundwater system. Recharge to the Pennsylvanian bedrock occurs from direct precipitation and infiltration in vicinity areas which are not paved or otherwise covered.

The wells installed in the glacial till, WBZ1, are relatively limited in number and do not reflect a broad enough area to characterize the gradient in that material. As with the water levels, the gradient in the glacial till soils is likely strongly influenced by the perched water on top of the Pennsylvanian bedrock (Figures 3.2.3-3 and 3.2.3-4).

The water levels in those wells that are installed on the former bluffs of the LVR valley or well arrays that straddle the bluff slope exhibit a pronounced gradient from west to east, from the uplands to the valley floor. Gradients in bedrock wells across the bluff area steepen to nearly 0.2 ft/ft, which represents the steeply sloping surface of the bedrock walls of the former valley. Cross sections C-C' and D-D', Figures 3.2.2-2 and 3.2.2-3, show the slopes of the valley wall as evident in boring logs, and illustrate that the slope of the water table mimics that buried bluff slope. The locations where the water table deviates from the slope of the buried bluff face are where the holding pond and emergency containment pond, constructed on the Slag Pile and railroad grade, offer a source of recharge which masks the water migrating along the bluff slope.

Those wells installed and screened in the slag, WBZ1, exhibit a pronounced gradient toward the east, mimicking the WBZ2 bedrock wells. Where bedrock is encountered at higher elevations, as at MW-301S, the water level in that well is also substantially higher. This suggests the water is travelling along the contact between the slag and the bedrock. Recharge to the slag materials is through direct precipitation and infiltration, or from groundwater discharging out of the Pennsylvanian bedrock or glacial till soils along the bluff face. Locally the slag deposits along the banks of the river are also recharged from the LVR during high river stages.

Wells screened in the alluvial soils in the LVR valley, WBZ1, show gradients influenced by the elevation of the adjacent river. The gradients show a trend of lower water levels to the south, downstream, with a component toward the LVR indicating some discharge is likely occurring from the bluffs to the river.

Water level measurements in the LVR and in the interstitial sampling points along the toe of the Slag Pile at the LVR indicate high river levels also result in recharge from the river into the banks, at least locally.

Vertical gradients between the two WBZs can be assessed at several locations on OU1 where multiple wells are installed at one location. Two wells are installed at MW-301S and -301H, at MW-303S and 303H, and at P-15 and P-15A. Three wells are installed at MW-305-S, -305H, and -305R.

At each of those locations, one of the wells is installed in the slag fill (those having the “-S” designation, and P-15A). The wells with the “-H” designation were installed in the Holocene alluvium. Wells P-15 and MW-305R were installed in bedrock. The relatively free-draining character of the slag wells results in there being a consistent vertical gradient downward, from the slag into the underlying material, whether that material is alluvial deposits or bedrock. (Note, however, at the MW-301 well nest, there is a considerable difference in the depths that the two wells were completed, which constrains accurate assessment of the vertical gradient.)

At the one nest which includes a bedrock and alluvial well (MW-305H and -305R) the vertical gradient between the rock and the alluvium is upward, which indicates groundwater is discharging from the rock into the alluvial deposits. This has been evident over several years of measurements, although the size of the vertical gradient has varied between survey events. While this upward directed gradient is evident in only one case, those data do suggest the bedrock is discharging into the valley fill alluvium rather than the water in the alluvium recharging the bedrock groundwater.

3.2.3.4 Summary of Hydrogeologic Conditions

OU1 is underlain by Pennsylvanian and glacial units that do not represent significant groundwater-producing horizons due to their generally low hydraulic conductivity. The more permeable units are represented by the sinter and slag fill and the Holocene alluvium. Those materials are limited to the floor of the LVR valley and the bluffs along the western side of the valley.

Seasonal variation in water levels is not evident in the wells in the Plant Area, likely as the result of the influence of man-made features such as pavements, subsurface drainage features, etc. In the areas without pavement cover, the water level appears to reflect seasonal fluctuations, with higher levels generally being measured in the winter and spring, and lower levels in summer and fall. The slag wells show sufficient variation so as to be dry in some survey events, reflecting the readily drained nature of this material.

The groundwater gradients across OU1 are significantly influenced by the majority of the Plant Area being covered by pavement and buildings. Recent repairs to drainage lines beneath the pavement have resulted in the water levels stabilizing, with gradients flat across most of the Plant Area, and becoming increasingly steep as one approaches the bluffs to the east. The slope of the groundwater appears to reflect the slope of the bedrock surface, with the exception of those areas where ponds have been constructed on the fill materials. These ponds act as local recharge points and result in local variations in the groundwater surface.

Recharge to the groundwater system occurs through infiltration of precipitation, and locally from high river stages in the LVR. The low hydraulic conductivity of the Pennsylvanian bedrock limits the amount of water moving through this unit, however, gradients indicate groundwater discharges from the bedrock along the bluffs of the LVR valley, recharging the Slag Pile which blankets the slope. Recharge to the alluvial valley fill also occurs from the bedrock. Groundwater gradients indicate discharge also occurs to the LVR from the bedrock and unconsolidated alluvium and slag deposits along the banks of the LVR.

3.3 OU2 FEATURES

The following sections discuss the OU2-specific setting. The OU2 soils ([Section 3.3.1](#)), geology ([Section 3.3.2](#)), and hydrogeology ([Section 3.3.3](#)) are discussed below.

3.3.1 Soils

The USDA NRCS identifies six different soil types within OU2: loamy undulating orthents, loamy rolling orthents, Marseilles silt loam with 2 to 5 percent slopes, Marseilles silt loam with 10 to 18 percent slopes, Marseilles silt loam with 35 to 60 percent slopes, and DuPage silt loam (Figure 3.3.1-1). Loamy undulating orthents are located in areas modified by construction activities, including cut-and-fill areas, borrow areas, and surface mining areas. Orthents are Entisol soils that lack horizon development because of steep slopes (USDA 2006). Loamy undulating orthents are present in the western and central parts of OU2 and occupy about 65 percent of OU2. Loamy rolling orthents are areas of disturbed soil materials normally located on moraines, outwash plains, and stream terraces. They usually are associated with backslopes of 6 to 12 percent (USDA 2006). Loamy rolling orthents are present in the southeastern part of OU2 and occupy about 12 percent of OU2.

Three areas within OU2 are classified as Marseilles silt loam, one area with 2 to 5 percent slopes, another with 10 to 18 percent slopes, and a final area with 35 to 60 percent slopes. The Marseilles series consists of well-drained and moderately well-drained soils formed in a thin layer of loess and the underlying

residuum from weathered shale (USDA 2006). The Marseilles silt loams with 2 to 4 percent slopes and 10 to 18 percent slopes each occupy only about 2 percent of OU2. The Marseilles silt loam with 35 to 60 percent slopes is located along the northeastern part of OU2 within the LVR valley slope and occupies about 18 percent of OU2.

DuPage silt loam consists of very deep, well-drained to moderately well-drained soil formed in alluvium (USDA 2007). This type of loam is present next to the LVR and occupies only about 3 percent of OU2. The DuPage silt loam, loamy rolling orthents, and loamy undulating orthents are included on the USDA NRCS's 2009 National Hydric Soils List. Hydric soils are one of three criteria for identifying wetland areas.

USDA NRCS-classified soils were confirmed during field work performed in Summer 2007 and are documented in the "Ecological Habitat Evaluation, Matthiessen and Hegeler Zinc Company, LaSalle County, Illinois OU2, Technical Memorandum, Internal Draft," presented in Appendix S-5.

3.3.2 Geology

The subsurface investigation at OU2 involved advancing 257 soil borings (Appendix S-1) and installing 36 MWs and 6 piezometers (Appendices S-3 and S-6). Based on observations during this investigation, the OU2 bedrock geology and unconsolidated overburden were established. Figure 3.3.2-1, Geologic Cross-Section A-A'-A'', and Figure 3.3.2-2, Geologic Cross-Section B-B'-B'', show cross-sections depicting the geology through both OU1 and OU2. In general, the geology at the Matthiessen and Hegeler Zinc Company Site is composed of Pennsylvanian-aged bedrock overlain by Quaternary-aged sediments and manmade or reworked materials. The unconsolidated Quaternary materials are heterogeneously deposited as there are many manmade fill deposits, indicating deposition, excavation, and reworking of much of the surface of OU2. The OU2 landscape was also dominated by both glacial and fluvial activity during the late Holocene as documented by the soil boring logs.

Currently, there are erosional features in the southern portion of OU2 where a topographic low exists north of the furnaces, as well as north/northwest of Building 1943. The area north of the furnaces is a topographic low (surface geology), which may have been geologically-related (see MW06 in Figure 3.3.2-1) while later manmade excavation likely occurred during Site operations, due to the presence of abandoned sewer-line, former railroad grade, etc. The area north/northwest of Building 1943 shows a relatively flat surface topography and an erosional or bedrock valley at depth as described in the soil

boring logs, which suggests a geologically-related erosional feature as both Pennsylvanian bedrock and Quaternary sediments are absent or lower in elevation in this area.

Natural gamma logging was also performed during the installation of MWs during Phase II of the RI activities. Typically, natural gamma logging is used to confirm described lithologies from soil borings for stratigraphic correlation (Figure 3.3.2-3). The gamma log provides a record of the total gamma radiation detected in a borehole within a selected energy range. Coal and limestone are less radioactive than shale (Keys 1989). Natural gamma logs collected during Phase II drilling activities confirm visual identification of the subsurface materials from soil boring logging. For example, Figure 3.3.2-3 compares the boring and gamma logs from MW MW35. Appendix S-1 provides all soil boring logs from MW installation, and Appendix S-7 provides natural gamma logs from MW installation.

OU2-specific geologic units, as shown in Figures 3.3.2-1 and 3.3.2-2, include the Bond Formation of the McLeansboro Group of the Pennsylvanian System (Pmc) and two lithologic sequences from the Quaternary System, the Lemont Formation (Qly) and the Equality Formation (Qe). Additionally, Quaternary-aged (late Holocene) artificial fill (Qaf) has been evaluated. Each unit is discussed in more detail below.

3.3.2.1 Bond Formation of the McLeansboro Group of the Pennsylvanian System

The Pennsylvanian-aged bedrock at OU2, consists of the Pmc. Throughout the remainder of this report and in Figures 3.3.2-1 and 3.3.2-2, the Bond Formation may also be referenced as solely Pmc. The Pmc is regionally characterized by a high percentage of limestone and calcareous clays and shales (ISGS 1975). Red claystones and shales are present in this formation and best developed in northern Illinois as seen on OU2 (ISGS 1975). As noted in OU2 soil boring logs, the Pmc is a horizontally bedded calcareous red and gray-green shale or claystone underlain by gray fossiliferous limestone interbedded with coal seams and gray shale or claystone. Across OU2, red shale ranges in thickness from approximately 5 ft thick (MW35) to approximately 19 ft thick (MW22). Gray shale ranges from approximately 1 to 2 ft thick (MW15 and DB02) to approximately 15 to 20 ft thick (MW25 and Pz1). The red and gray shales are mostly continuous across OU2 except in the topographic low area north of the furnaces (see MW06 in Figure 3.3.2-1), where there appears to be an erosional gully/valley where the top 10 to 15 ft of the Pmc is not present. Additionally, no borings in this area reached either the shale or limestone member of the Pmc.

Underlying the red and gray shale bedrock is the gray fossiliferous limestone. The Pmc limestone contains interbeds of shale or claystone which range from 0.04 to 0.5 inches thick as well as coal seams which range from approximately 0.25 inch to 2 ft thick (DB01 and MW35). Small fossils were also observed in the Pmc limestone. Brachiopods were abundant in the limestone bedrock cores from DB01, DB02, and borings from MW18, MW25, MW32, and MW35. Crinoid fossils were observed in DB01 and DB02 bedrock cores. The less common bryophyte fossil was observed in bedrock core DB01. In addition, calcite-filled vugs were recorded in bedrock core DB02. Pyrite mineralization was observed in borings MW20, Pz1, and bedrock core DB01.

In general, the Pmc shale typically appears moderately to extremely fractured both in contact with the overlying younger formations and the underlying limestone. Trace silt in some of the fractures within the shale suggests that water flows through these fractures. Both the Pmc upper shale contact and the Pmc lower shale/upper limestone contact show weathering in some soil boring locations on OU2. The Pmc shale member was seen as shallow as 592.77 ft above msl (MW01, 8 ft bgs) and the Pmc limestone member was documented as deep as 483.18 ft above msl (DB01, 90 ft bgs). None of the on-site borings was deep enough to penetrate the entire thickness of the limestone member. The Pmc purportedly is 225 ft thick in the LaSalle region of Illinois (ISGS 1975), however, the Pmc also has been cited as ranging from about 60 to 120 ft in thickness in this region (Konsake et al. 1960; Jacobson 1983).

Phase I boring logs often characterize platy gray and red shale or claystone solely as red or gray “clay”, or red or gray “silty clay”. However, in Phase II boring logs this terminology was modified to red or gray “shale” as additional borings were drilled and further observations were made and correct characterizations were made. Therefore in several geologist logs from Phase I soil borings the Pmc is indicated as red or gray “clay”, while geologist logs from Phase II soil borings indicate red or gray “shale”.

Deep borings logs from DB01, DB02, MW25, and MW35 indicate evidence of cyclothems. Cyclothems are documented throughout the Illinois Basin and have been suggested as having been created during the Pennsylvanian Period. Cyclothems are interpreted as a succession of rapid and frequent changes in depositional environments producing 10 cyclical layers of marine and non-marine sedimentary units such as sandstone, shale, clay, limestone, and coal in response to a shifting shoreline of an ancient sea. Individual sedimentary facies range from a few inches to 30 ft thick (ISGS 2000). Although there has been no field documentation of an ideal 10-cycle cyclothem preserved, partial cycles are commonly recorded throughout the Illinois Basin. At OU2, the deep boring logs from DB01, MW25, and MW35 show partial cyclothem depositional facies.

3.3.2.2 **Lemont Formation**

The Qly is ubiquitously present across OU2. The predominant clast lithologies consist of Paleozoic shales and carbonates. Locally, Qly includes a glacial till facies that is typically gray to brown/tan in color and calcareous, and that has a grain size ranging from silty clay to sandy loam to gravel. The Qly has been interpreted as subglacial and ice-marginal facies of several off-lapping, glaciogenic sequences. The Qly unconformably overlies the Pennsylvanian bedrock. Soil boring logs describe the predominant presence of silty clays, sandy gravels, and sandy loams which extend over the majority of OU2. The Qly extends from 607.96 ft above msl (MW15) to 564.86 ft above msl (MW03). Typically, the Qly extends down to approximately 580 to 578 ft above msl across the majority of OU2 where it contacts the Pmc (Figure 3.3.2-1). However, in the topographic low areas, near the Rolling Mill and north of the furnaces, the contact is documented 10 to 14 ft lower (e.g. MW03, SB187).

3.3.2.3 **Equality Formation**

The Qe consists of lacustrine sediment of brown to gray to red bedded silt and clay deposited in glacial and post-glacial lakes. Soil boring logs show that the Qe is present in the southern portion of OU2 in the topographic low near MW06, MW07, and SB123 (Figure 3.3.2-1) and unconformably overlies the Pennsylvanian bedrock. This situation suggests that in this area, erosion, possibly glacial or fluvial, removed some of the Pmc and all of the Qly lithologies prior to the deposition of Qe. The Qe is discontinuous and thin (29 ft thick), ranging from 560.5 (MW06) ft above msl to at least 531.23 (MW07) ft above msl, which is the deepest boring measurement obtained for this formation, although no contact between the Qe and the Pmc was observed or noted.

3.3.2.4 **Artificial Fill**

Artificial fill (Qaf) is Quaternary-aged (late Holocene) and includes all materials deposited or reworked by human action since the onset of industrial operations at the Matthiessen and Hegeler Zinc Company Site. Specifically, activities may have included construction, mining, and quarrying, and the fill may have been compacted engineered fill as well as non-compacted, non-engineered fill. OU2-specific fill material consists mainly of sinter, slag, small pieces of building debris (brick, stone, mortar, etc.), reworked soil, glacial tills and other Quaternary-aged sands, silts, and clays, and reworked Pennsylvanian-aged shale and limestone.

Slag is recrystallized oxide residue (vitrified silicate) remaining after metal production from ore. OU2 slag ranges in from moderate red to blackish-red and has a highly porous, vesicular texture similar to

scoria. Much of the slag appears to have become welded into large blocks through the slag's own heat before and during deposition. Welded slag blocks can be fractured, especially during on-site boring activities. At OU2 during investigations of samples from the subsurface, slag would often appear as gravel-sized grains or would cause refusal to the entire Geoprobe® drilling assembly.

Sinter, an intermediate product of zinc production, is produced when zinc sulfide ore is roasted, driving off sulfur and resulting in oxidized zinc. This oxidized zinc sinter consists of black, medium sand-sized, loose granular material.

Soil boring logs from the 257 borings installed during two phases of investigation at OU2 indicate that Qaf covers a significant portion of OU2 (Figure 3.3.2-1). Significant fill deposits were observed mainly in the central portion of OU2, the former main industrial area. The fill along the perimeter of OU2 extends from 0.5 ft bgs (SB422) to 4.5 ft bgs (SB403). The thickest fill deposit extends to 33.5 ft bgs at MW27. The varying thickness of fill material logged around OU2 indicates that the sinter and slag material was used both as construction material and disposed of or backfilled in topographically low areas.

3.3.3 Hydrogeology

Two WBZs were investigated during the hydrogeologic investigation of OU2. The shallow zone, WBZ1, consists of unconsolidated materials. These unconsolidated materials consist of Quaternary-aged sands, silts, glacial tills, and artificial fill materials (slag, sinter, brick, reworked soils, and Site geologic materials). WBZ2 consists of the underlying shale bedrock discussed in [Section 3.3.2.1](#) as part of the Pennsylvanian Formation as well as the very top (0 to 2 ft) of the limestone bedrock. Table 3.3.3-1 lists the MWs and piezometers and their WBZ designation at OU2. Also included in Table 3.3.3-1 are the screened intervals and soil boring lithologies for each MW at OU2. Several MWs were partially screened in the unconsolidated overburden as well as the underlying bedrock. In this case, a WBZ determination for each of these MWs was made based on the following: 1) depth of water-bearing formation at MW installation (e.g. which WBZ is the water originating from); 2) length of screened portion of MW in each WBZ; and 3) stability of water levels in that MW, as bedrock aquifers typically exhibit more stable readings during seasonal changes in precipitation compared to unconsolidated aquifers.

Equilibrated groundwater elevations were measured at the start of each quarterly groundwater sampling event. Table 3.3.3-2 lists the measured groundwater elevations for all quarters to date. Based on data

collected during RI activities, hydraulic properties were evaluated for each WBZ. Hydraulic conductivity and groundwater flow for each WBZ are discussed below.

3.3.3.1 Hydraulic Conductivity

In October 2008, SulTRAC performed hydraulic conductivity tests at 12 MWs. These MWs were selected according to their recharge characteristics observed during groundwater sampling events and the screened interval lithology of the MW. The hydraulic conductivity tests also are known as slug tests, which are a type of aquifer test where a known quantity of water or a solid slug is quickly added (falling head test) or removed (rising head test) from a MW. The change in hydraulic head is monitored through time until equilibrium is achieved. The hydraulic conductivity of the formation in the immediate vicinity of the MW can then be established based on these measurements. To preserve the integrity of the data, replication of results is necessary. Three falling or rising head tests were conducted at each MW. Available data were evaluated further using the Hvorslev method (Appendix S-4) and grouped according to aquifer type to establish conductivities of the formations around the MWs (Hvorslev 1951). An average hydraulic conductivity was calculated from the three tests results for each MW. Table 3.3.3-3 lists the hydraulic conductivities, or k values, derived from the slug tests.

Of the 12 MWs used for slug tests, 8 are screened within WBZ1. WBZ1 unconsolidated materials consist primarily of Quaternary-aged sediments, sands, gravels, silts, and till, or fill materials (sinter, slag, brick) and reworked sediments. Five MWs, MW06, MW07, MW09, MW15, and MW17 were all screened in Quaternary-aged sediments, typically components of glacial till, which ranged from sand, silt, and silty clay (MW06), sand and gravel (MW07), sand, clay, silty clay (MW09), sand and silty clay (MW15), and silt, sand, and silty clay (MW17). These sediments all reflect typical grain sizes of the glacial till member within the Qly. The average hydraulic conductivity values of these MWs, MW06, MW07, MW09, MW15, and MW17 were 3.19×10^{-4} , 1.43×10^{-2} , 6.42×10^{-4} , 4.52×10^{-3} , and 3.55×10^{-4} centimeter per second (cm/s), respectively. These hydraulic conductivity values fall within the typical range for sandy silts and silty clays (Driscoll 1986) and indicate moderate permeability characteristic of these Quaternary-aged sediments. MW06, MW07, MW09, and MW17 are located within the central portion of the former main industrial area, while MW15 is located in the northern forested region of OU2.

An additional three wells, MW24, MW25, and MW29 were also screened within WBZ1, within the fill materials consisting primarily of artificial materials such as slag, sinter, and brick along with some reworked Quaternary sediments. These materials are compacted, highly variable, with seemingly variable porosity. MW24 was screened in a slag, sinter, and sand mix, and MW25 was screened in a sand, silt,

sinter, slag, and brick mix underlain by silty clay. The top 5 ft of the 10-ft screen in MW29 was set in sand, gravel, sinter, brick, and slag mix, underlain by Pennsylvanian-shale in the bottom 5 ft of screen. MW29, as discussed above, is classified as WBZ1, as the saturated area was found within the fill materials, and its water level measurements were variable over time, indicating WBZ1 as the source of groundwater for this well. The average hydraulic conductivities of these MWs, MW24, MW25, and MW29, were 9.55×10^{-3} , 4.42×10^{-4} , and 2.16×10^{-4} cm/s, respectively. These values indicate semi-pervious permeability, characteristic of a poor aquifer of fine sands and silts (Bear 1972). MW24 and MW25 are located within the central portion of the former main industrial area, and MW29 is located just west of the Rolling Mill.

Four of the twelve wells selected for slug testing were screened in WBZ2. MW18, MW19, and MW20 are located along the east side of OU2, while MW23 is located in the northwestern portion of OU2. MW19, MW20, and MW23 were screened solely in the shale bedrock, while MW18 was screened in 9.5 ft of shale and 0.5 ft of limestone bedrock. The average hydraulic conductivity for MW19, MW20, and MW23 are 2.20×10^{-6} , 5.59×10^{-5} , and 3.95×10^{-4} cm/s, respectively. Depending on the degree of fracturing of the shale, the hydraulic conductivity values for shale characteristically range from 1×10^{-3} to 1×10^{-7} cm/s (Driscoll 1986). It appears that these MWs were screened in moderately fractured shale. The average hydraulic conductivity for MW18 is 7.90×10^{-4} . The hydraulic conductivity for limestone typically ranges from 1×10^{-7} to 1×10^{-8} (Bear 1972), therefore the slug test results indicate that most of the groundwater in MW18 is likely flowing through moderately fractured shale as is the case for the other three WBZ2 MWs.

3.3.3.2 Groundwater Flow

Table 3.3.3-2 shows the quarterly groundwater elevation readings collected from each MW and piezometer. Figures 3.3.3-1 and 3.3.3-2 show groundwater elevation readings collected in September 2008 depicted as a potentiometric surface for WBZ1 and WBZ2, respectively. Figures 3.3.3-3 and 3.3.3-4 show the groundwater elevation readings collected in December 2008 depicted as a potentiometric surface for WBZ1 and WBZ2, respectively. Results from these two quarterly events were selected because the timing of the events represented the wettest season (September) and the driest season (December) for the Matthiessen and Hegeler Zinc Company Site.

The potentiometric surface drawings show that the WBZ1 is a continuous system in the unconsolidated overburden material, with most groundwater flow to the east and southeast. During September 2008 (wet period; see Figure 3.3.3-1), the WBZ1 gradient was relatively flat to the east and southeast, ranging from

0.02 to 0.03 ft/ft over most of OU2. These gradients were measured in the vicinity of MWs MW02S, MW27, MW31, MW04, and MW06 as well as MW24, MW09, MW25, and Pz5. In the southeastern portion of OU2, the gradient in the vicinity of MW07 and MW08 was 0.05 ft/ft. A steeper gradient (0.13 ft/ft) exists to the east in the vicinity of MW11, MW12, and MW21. This steep gradient coincides with a 30 to 40 ft decrease in ground surface elevation in this portion of the Site.

During December 2008 (dry period, see Figure 3.3.3-3), the WBZ1 gradient was fairly similar to that measured during the September 2008 wet period. Generally, the WBZ1 gradient flows east to southeast and ranges from 0.02 to 0.03 ft/ft over most of OU2. These gradients were measured in the vicinity of MWs MW02S, MW27, MW31, MW04, MW06, MW24, MW09, MW25, and Pz5. The gradient in the vicinity of MW08 and MW07 was also measured at 0.05 ft/ft. The steepest gradient, as in WBZ1 in September 2008, is to the east (0.12 ft/ft) and in the vicinity of MW11, MW12, and MW21.

Overall, the WBZ1 gradients did not change between the September 2008 wet period and December 2008 dry period, over much of OU2. The only difference occurred in the steepest area (MW11, MW12, MW21), where the gradient differed by 0.01 ft/ft.

Gradient calculation methods used in this investigation assumed that the aquifer is a porous medium. As documented in soil boring logs and during other intrusive work, WBZ2 consists of fractured bedrock. To apply porous media analytical methods to a fractured bedrock system, which is likely the situation as described in the OU2 soil boring logs in the shale and limestone bedrock, a simplifying assumption was used that the bedrock is homogeneously fractured and interconnected across OU2 and acts as an equivalent porous medium. Although local flow may occur along fractures rather than downgradient, overall flow in a fractured interconnected medium will follow the gradient.

The potentiometric surface for WBZ2 during the September 2008 wet period (Figure 3.3.3-2) shows a fairly consistent gradient in the former main industrial area, ranging from 0.04 to 0.06 ft/ft, with groundwater flow in an easterly direction towards the LVR. These gradients in the vicinity of MWs MW28 and MW05 was measured at 0.04 ft/ft, MW14 and MW20 was measured at 0.05 ft/ft, and MW14, MW23, MW22 was measured at 0.06 ft/ft. In the southern portion of OU2, the gradient in the vicinity of MW32, MW33, MW05 was steeper (0.10 ft/ft) and in the northeast direction. Although at the surface the topography is fairly flat, a bedrock valley, potentially an erosional surface, is indicated via soil boring descriptions and drawn cross-sections, in this area of the Site. This change in bedrock surface elevation could account for the steeper groundwater gradients in the vicinity of MW32, MW33, and MW05. A

steeper gradient (0.16 ft/ft) exists to the east in the vicinity of MW19 and MW18. The steep gradient in the vicinity of MW18 coincides with a 60 to 70 ft bedrock bluff, with MW18 located at the base.

The potentiometric surface for WBZ2 during the December 2008 dry period (Figure 3.3.3-4) overall shows flat gradients in the former main industrial area, ranging from 0.02 to 0.06 ft/ft and flowing in an easterly direction towards the LVR; a similar gradient range and groundwater flow directions as those described from the September 2008 wet period. These gradients in the vicinity of MWs MW28 and MW05 were measured at 0.02 ft/ft, MW14 and MW20 were measured at 0.05 ft/ft, and MW14, MW23, and MW22 were measured at 0.06 ft/ft. The areas with steeper groundwater gradients shown in the September 2008 wet period, exhibit variable responses in these same areas during the December 2008 dry period. The gradient (0.05 ft/ft) in the vicinity of MW32, MW33, and MW05 is shallower, while a steeper gradient (0.20 ft/ft) exists in the vicinity of MW19 and MW18. The flow directions remain constant for both periods in which water levels were measured.

3.4 SITE-WIDE INTERPRETATION

The interpretations of site-wide soils, geology, and hydrogeology are presented below.

3.4.1 Soils

Figure 3.4.1-1 shows the site-wide soils as identified by the USDA NRCS. Site-wide soils at the Matthiessen and Hegeler Zinc Company Site generally fall into one of the following classifications: loamy undulating orthents, loamy rolling orthents, or a variation of silt loam. Because the Site contains highly disturbed, industrialized areas, soils range from non-existent to loamy undulating orthents. This type of low soil development occurs in slag piles, along the banks of the LVR, in the OU1 Carus facility area, and in the OU2 former main industrial area. Various types of silt loam (Marseilles and DuPage) are located in the more vegetated areas of the Matthiessen and Hegeler Zinc Company Site because these types of areas support well- to moderately well-drained soils. These silt loam soils are located in the north, northeast, and southern portions of the Matthiessen and Hegeler Zinc Company Site.

3.4.2 Geology

This section describes the geology of the Matthiessen and Hegeler Zinc Company Site as a whole, that is OU1 and OU2 collectively. The overall Site geology was developed considering the subsurface investigations conducted separately on OU1 and OU2. Core samples were collected site-wide, and the interpreted subsurface geology displayed along four geologic cross-sections across the Site (Figures 3.3.2-

1 and 3.3.2-2). The A-A'-A'' cross-section runs north to south across the Site, including both OU1 to the south and OU2 to the north. The B-B'-B'' cross-section runs as a diagonal from the northwest to southeast across the Site, primarily in OU2, with the eastern end at the north portion of OU1. The C-C' and D-D' cross-sections run west to east across OU1.

The subsurface investigation of OU1 involved drilling 49 soil borings, and installing 22 MWs and piezometers. The subsurface investigation of the OU2 involved drilling 257 soil borings, and installing 36 MWs and 6 piezometers. The results of the subsurface investigation are shown graphically in Figures 3.3.2-1 and 3.3.2-2. Table 3.4.2-1 lists the major geologic formations categorized by era, system, series, and group.

Each geologic unit (from youngest to oldest in geologic time) is described in the following sections and summarized as follows:

- Artificial Fill (Qaf), which includes all materials which have been deposited or reworked by human action since the onset of industrial operations
- Cahokia Formation and the Holocene alluvium (Qal), stream channel and flood plain deposits which include dark gray to black stratified silt, sand, and some gravel
- The Equality Formation (Qe), a lacustrine or quiet water deposit which includes brown to gray to red bedded silt and clay
- The Lemont Formation (Qly), a glacial till deposit which includes several different lithologies of coarse till, fine till, and silty clay
- The Pmc is the oldest geologic unit, and includes the bedrock shale, limestone and coal units, and residual soils formed on it

Each geologic formation is discussed in greater detail in the following sections, consisting of a systematic description of each of these formations including: 1) overall makeup and distribution; 2) internal composition; and 3) a general description of hydrogeologic properties, if applicable.

3.4.2.1 Artificial Fill

Modern artificial fill deposits (fill deposits) include all materials which have been placed or reworked by human action since the onset of industrial operations at the Site. Fill deposits resulting from human construction, mining, and quarrying activities include compacted engineered and non-compacted, non-engineered fill. Fill deposits are scattered across parts of OU2, with the larger volume of fill deposits located on OU1. Fill deposits were observed to cover large areas of OU1 and OU2. Significant deposits

were found in the central part of the OU1 Plant Area where they constitute the infill material for a former erosional gully, described more fully in [Section 3.2.3.1](#). The largest deposit of this material is represented by the Slag Pile located along the western side of the LVR in OU1. Borings in the Slag Pile measured thicknesses of slag in excess of 100 ft (P-22). Soil boring logs from the borings installed at OU2 indicate that artificial fill covers most of the Site. Significant fill deposits were observed mainly in the central portion of OU2 where the main industrial operations occurred. The fill is located from 0.5 ft bgs (SB422) to 4.5 ft bgs (SB403) along the edges of OU2. The largest thickness of sinter and slag fill material was recorded at MW27 at 33.5 ft bgs. The varying thickness of fill material logged around OU2 indicates that the sinter and slag material was likely used to fill in depressions.

The fill deposits are both complex and significant to the flow and potentially to the quality of groundwater. In general, the following types of fill deposits were observed: 1) soil fill; 2) sinter; and 3) slag. Each type of fill deposit is described below.

- **Soil Fill** - Soil fill consists primarily of reworked Pennsylvanian shale and glacial till. The reworked shale and till appear to have been derived from residual soil developed in the top of the Pennsylvanian bedrock and from the glacial till deposits. The reworked fill soil is characterized by a loosely compacted jumble of shale and siltstone clods with a small amount of miscellaneous fill material including building debris, ceramic remnants from the smelting operations, and other debris. In addition to the reworked shale, the following other types of fill soils were investigated: sediments dredged from some of the on-site ponds, structural fill associated with the ICRR grade, miscellaneous shallow fill and road gravel, and compacted clay liner installed locally for lining some of the storage ponds.
- **Sinter Fill** - Sinter, in the context of zinc production, is an intermediate product consisting of agglomerated zinc oxide. Sinter is produced when zinc sulfide ore is roasted, which causes the sulfur to be driven off and the zinc to oxidize. The sinter found in the fill deposits is presumed to have been off-specification material. Where encountered in the borings, the sinter consisted of black, loose granular material, the size of medium sand.
- **Slag Fill** - Slag is the recrystallized or vitrified silicate and oxide residue from the production of metal from ore. Typically, slag ranges in color from moderate red to blackish red and has a highly porous, cindery, vesicular texture similar to scoriaceous lava rock. Much of the slag appears to have become welded into large blocks by its retained heat prior to and during deposition. Slag deposits observed in outcrops site-wide were extremely porous with large, interconnected voids on the order of 0.3 to 1.0 ft across.

3.4.2.2 Cahokia Formation and Holocene Alluvium

The most recent (youngest) geologic formations are the Cahokia Formation and the Holocene alluvium (Qal); without detailed geological dating analyses, these formations cannot be differentiated. The Cahokia and Holocene alluvium of the Pleistocene Series of the Quaternary System are the youngest non-anthropogenic geologic formations found at the Site. These units are evident along the LVR channel and beneath portions of the Slag Pile. Cahokia and Holocene alluvium were only found at OU1 (Figures 3.2.2-1 through 3.2.2-3).

Alluvial deposits appear to be confined to the valley of the LVR, and consist mainly of loose sandy gravel, silty sand and sandy silt. The depth of the alluvial deposits is unknown. The alluvial deposits are believed to be of Holocene age (within the past 10,000 years), but a Pleistocene component (Cahokia) may also be present. In the section of the river that flows by OU1, portions of the alluvial deposits have been buried by deposits of slag.

Figures 3.2.2-1 through 3.2.2-3 show the alluvial deposits mixed with slag beneath the Slag Pile. At greater depths, the alluvium is present with no admixture of slag. In Boring P-17, which encounters weathered green shale bedrock beneath the alluvial deposits, the alluvium extends to a depth of 20 ft beneath the base of the slag. However, it is not clear that this boring penetrates the thickest section of the alluvial valley fill deposits.

3.4.2.3 Equality Formation

The Qe of the Pleistocene Series of the Quaternary System is the third oldest geologic formation found on the Site. The Qe consists of lacustrine sediment of brown to gray to red, bedded silt, and clay deposited in glacial and post-glacial lakes. The majority of the Qe was found at OU2.

Soil boring logs suggest that the Qe overlies the Pennsylvanian bedrock and extends over the south-southwest portion of OU2. The layer is thin and is approximately 2 ft thick at MW06, ranging from 560.5 (MW06) ft above msl to at least 531.23 (MW07) ft above msl (Figure 3.3.2-1).

3.4.2.4 Lemont Formation

The Qly is the second oldest geologic formation mapped on the Site. Qly was found at both OU1 and OU2 (Figure 3.3.2-1). The Qly consists of glacial till subglacial and ice-marginal facies of several off-lapping, glacial sequences. The Qly is mostly present on the northwestern portion of the Matthiessen

and Hegeler Zinc Company Site. The predominant clast lithologies consist of Paleozoic shales and carbonates.

Within OU1, Qly till is generally confined to the upland areas under the main plant (Figure 3.2.2-2) where it is mostly covered by buildings and pavement. The Qly is exposed in some portions of OU2, and overlain by artificial fill in other areas (Figure 3.3.2-1). The Qly overlies the Pennsylvanian bedrock. The till is present as an approximately 10-ft thick section in the northwest part of the OU1 Plant Area (MW-311R, Figure 3.2.2-3), is thinner beneath much of OU1, and thickens in G-101, G-103 and P-6 (Figure 3.2.2-3) near the northeast corner of the Plant Area, where it is up to approximately 20 ft thick. The glacial till in OU2 extends from 607.96 ft above msl (MW15) to 564.86 ft above msl (MW03) and the glacial till typically extends down to approximately 580 to 578 ft above msl across the majority of OU2 where it contacts the Pmc (Figure 3.3.2-1).

The till is comprised of several different lithologies: 1) coarse till; 2) fine till; and 3) silty clay. Soil boring logs suggest that silty clays and sandy loams with limestone, gray shale, and a few coal clasts characterize the till in the northwest portion of OU2. The clasts range from 2 to 10 mm in size.

3.4.2.5 McLeansboro Group

The Pmc is the oldest geologic unit found on both OU1 and OU2. The Pennsylvanian units constitute the bedrock and underlie the entire area around both OU1 and OU2. Within the area of investigation, the bedrock consists of horizontal or nearly horizontal layers of shale and limestone with a few thin beds of coal and sandstone. In many areas, a mantle of residual soil has developed within the upper few feet of the Pennsylvanian deposits. The McLeansboro Group includes the following various rock types, 1) green shale, which includes some coal and gray claystone; 2) red shale; 3) limestone; and 4) gray shale with thin beds of limestone.

Figures 3.3.2-1 and 3.3.2-2 show the bedrock formation. The Pennsylvanian-aged bedrock at OU2 consists of horizontally interbedded red and gray-green shale and fossiliferous gray limestone interbedded with thin coal seams and gray clay layers ranging from 1 to 13 mm thick. In general, the Pennsylvanian-aged shale typically appears moderately to extremely fractured both in contact with the overlying younger formations and the underlying limestone. Fracturing may create preferential flow pathways at these interfaces.

The Pennsylvanian-aged lithology is not well exposed on OU1, although the type sections for several members (Bond Formation, LaSalle Formation, and Vermilion Formation) of the McLeansboro Group are

exposed on the bluffs on the east side of the LVR opposite the Matthiessen and Hegeler Zinc Company Site (Willman, et al., 1975). Additionally, the Pennsylvanian-aged section is not penetrated for any significant length in any of the borings on OU1, although portions of the section over a nearly 150 ft thickness are encountered in different borings. Borings encountering the Pennsylvanian-aged section extend from elevation approximately 573 ft at the Plant Area in borings MW-311R, C-3, G-05, C-9, G-01 (Figure 3.2.2-2); and MW-317R, C-13 and G-02 (Figure 3.2.2-3), down to borings encountering bedrock at elevation 428 ft in SB-309, and 433 ft in P-17 (Figure 3.2.2-3).

Limestone bedrock is encountered in the Plant Area of OU1 as the uppermost bedrock unit (MW-311R, MW-317R, and C-13) (Figure 3.2.2-2 and 3.2.2-3). Green shale is also evident in the bedrock in the Plant Area in borings C-3 and G-05 (Figure 3.2.2-2). Red shale is intermixed with the green shale in borings C-9 and G-01 deeper in the Pennsylvanian section (Figure 3.2.2-2). The bedrock beneath the Slag Pile in OU1 down slope from the Plant Area is encountered on relatively few borings, but appears to be a reddish brown shale in borings MW-306S and SB-320H (Figures 3.2.2-1 and 3.2.2-2, respectively). Beneath the alluvium in the lowermost sections of bedrock encountered on OU1, the strata include weathered green shale (P-17), limestone bedrock (SB-309), and green shale (P-15) (Figure 3.2.2-1).

A relatively thin, but highly fractured coal bed was noted in boring G-02 (Figure 3.2.2-3). The strata above and below that horizon were described as dry, although the boring log describes water in the borehole upon penetrating the coal. This suggests the coal is much more transmissive than the shale and limestone material above and below that horizon.

Limestone bedrock is continuous across the OU2 area (Figure 3.3.2-1). Deep borings indicate gray fossiliferous limestone at elevations ranging from 481.18 above msl (90 ft bgs) at its deepest point in boring DB01 to 592.77 above msl (8 ft bgs) at its shallowest point in boring MW01. None of the borings on-site was deep enough to penetrate the entire thickness of the limestone. The Pmc purportedly is 225 ft thick in the LaSalle region of Illinois (ISGS 1975), however, the Pmc also has been cited as ranging from about 60 to 120 ft in thickness in this region (Konsake et al. 1960; Jacobson 1983).

The limestone is overlain by beds of red and gray shale across OU2. Red shale ranges in thickness from approximately 5 ft (MW35, Figure 3.3.2-1) to approximately 19 ft (MW22,). Gray shale ranges in thickness from approximately 1 to 2 ft (MW15 and DB02, Figure 3.3.2-1 to approximately 15 to 20 ft (MW25 and Pz1, Figure 3.3.2-2). The red and gray shales are mostly continuous across OU2 except in the topographic low area north of the furnaces (MW06 in Figure 3.3.2-1), where there appears to be an erosional gully/valley where the top 10 to 15 ft of the Pmc is not present. Initial OU2 (Phase I) soil

boring logs characterize platy gray and red shales as clay. However, this terminology later was revised to red and gray shale as additional borings were drilled and further observations were made.

Gray clay layers are interbedded in the shale and limestone bedrock. The gray clay is approximately 0.04 to 0.5 inches thick, platy, calcareous, and unlaminated (logs for borings DB01 and DB02 in Figures 3.3.2-1 and 3.3.2-2, respectively). Coal seams range in thickness from approximately 0.25 inch to 2 ft (DB01 and MW35, Figure 3.3.2-1). These coal seams are discontinuous and interbedded in the gray shale and limestone. Small fossils were also observed in the Pmc limestone. Brachiopods were abundant in the limestone bedrock cores from DB01, DB02, and borings from MW18, MW25, MW32, and MW35. Crinoid fossils were observed in DB01 and DB02 bedrock cores. The less common bryophyte fossil was observed in bedrock core DB01. In addition, calcite-filled vugs were recorded in bedrock core DB02. Pyrite mineralization was observed in borings MW20, Pz1, and bedrock core DB01.

3.4.3 Site-Wide Hydrogeology

The hydrogeologic conditions at the Matthiessen and Hegeler Zinc Company Site can generally be described as consisting of two WBZs, WBZ1 within the unconsolidated deposits, and WBZ2 within the bedrock units. Figures 3.2.3-2 through 3.2.3-5 present the site-wide potentiometric maps for WBZ1 and WBZ2. There are local variations in these WBZs due to the significant topographic variation between the upland areas, the river valley bluffs and the valley floor along the LVR. These variations are described in terms of the groundwater gradients, hydraulic conductivity, and other properties in the following sections.

3.4.3.1 Hydraulic Conductivity

Hydraulic conductivity was measured in slug tests and pump tests in MWs and piezometers site-wide. Values of hydraulic conductivity for specific MWs and piezometers can be found on Tables 3.2.3-1 and 3.3.3-3 for OU1 and OU2, respectively.

Within WBZ1, there is significant variation in the measured values, likely due to the wide range of materials which contain this WBZ. In OU1, the majority of the unconsolidated materials consist of slag along the bluff slopes and in the LVR valley, with lesser amounts of glacial till and soil fill in the upland areas, and alluvial deposits along the LVR valley floor. In OU2, there are extensive areas of slag and soil overlying the bedrock, however virtually no alluvial material was encountered, in that OU2 does not include the LVR valley floor. The measured hydraulic conductivity in WBZ1 materials ranged from 1.6×10^{-4} cm/sec (P-6) in the glacial till deposits to 2×10^{-1} cm/sec (MW-1) in the slag materials. The alluvial and soil fill materials fell somewhere between these values.

WBZ2, within the Pennsylvanian-aged bedrock, also exhibits a wide range of measured hydraulic conductivity values. This range in values likely is the result of MWs being completed in both intact bedrock, and more weathered and fractured materials near the surface of the bedrock. Furthermore, the Pennsylvanian-aged units include a range of lithologies including shale, limestone, and coal. Hydraulic conductivity values measured in WBZ2 ranged from 2.2×10^{-6} cm/sec (MW19) to 3.95×10^{-4} cm/sec (MW23). The lower values hydraulic conductivity values in WBZ2 suggest that with the exception of the near surface weathered bedrock, the potential for infiltration and transport of contaminated groundwater in the Pennsylvanian bedrock is reduced compared to WBZ1.

3.4.3.2 Groundwater Gradients

Groundwater flow within WBZ1 seems to be a continuous system site-wide with fairly flat gradients. In OU1, the wells in WBZ1 are limited to the far eastern edge of the Plant Area and the Slag Pile. Gradients in these wells trend to the east, toward the LVR, and are relatively steep, 0.08 to 0.12 in the Plant Area to 0.3 or higher in the Slag Pile. Within OU2, WBZ1 gradients flow to the east and southeast and do not seem to reflect much of a change (± 0.01) in gradient between the wet (September 2008, Figure 3.3.3-1) and dry (December 2008, Figure 3.3.3-3) seasons. Figures 3.3.2-1 and 3.3.2-2 show approximate water levels measured in MWs along the alignment of the cross sections.

Site-wide gradients in WBZ1 are relatively flat in the upland areas, ranging from 0.01 ft/ft, to as steep as 0.05 ft/ft (Figures 3.2.3-2 and 3.2.3-4). The steeper gradients in WBZ1 tend to be toward the eastern section of the Site approaching the LVR valley bluffs (G-04, G-103 and G-106) as well as in the OU2 topographic transition from the OU2 uplands to lower topography west of the former railroad grade (MW11, MW12, and MW21 in Figures 3.2.3-2 and 3.2.3-4). In the plant area of OU1, gradients are somewhat flatter, in the range of 0.01 to 0.02 ft/ft, likely as a result of limited recharge due to the majority of the area being paved or occupied by buildings.

Near and along the bluffs of the LVR valley in OU1, the gradients in WBZ2 range as steep as 0.2 ft/ft, likely representing the approximate slope of the lower permeability bedrock slope. Similar gradients are evident in OU2 near MW32 and MW18, with gradients toward the northeast and east of 0.1 ft/ft and 0.2 ft/ft, respectively (Figures 3.2.3-3 and 3.2.3-4). These MWs are screened in the Pennsylvanian-aged shale and likely reflect the gradient in WBZ2. In MW18, the steep WBZ2 gradient is likely due to the flow of groundwater discharging from the Site, along the bluff face and ultimately to the LVR. Elsewhere WBZ2 generally has a flatter eastward trending gradient ranging from 0.02 ft/ft to 0.06 ft/ft. This general eastward trend likely reflects the gentle low-grade dip of the bedrock strata to the east.

3.4.3.3 Recharge and Discharge

Recharge to the site groundwater is generally through infiltration of precipitation site-wide. There may also be some local infiltration of surface water along the intermittent channels and standing water near the center of OU2, although there is likely some surface water and groundwater flow into the abandoned sewer, which subsequently drains into a surface channel tributary to the LVR. Locally, recharge also occurs intermittently along the banks of the LVR during high river stages. Infiltration is limited in the plant portion of OU1 due to the majority of the area being paved or occupied by buildings. Some recharge may occur off-site to the west into the Pennsylvanian bedrock, given the slope of those strata to the east, and the apparent flow from the bedrock into the WBZ1 Slag Pile along the bluff slopes to the east.

Groundwater discharge appears to occur at several areas. The steepening slope of the potentiometric gradient approaching the bluffs along the LVR suggests the groundwater may flow from the bedrock surface forming the bluff slopes beneath the Slag Pile. This groundwater flow is likely occurring from the bedrock WBZ2 into the overlying WBZ1. In OU1, a nest of MWs in the bedrock and overlying alluvial deposits (MW-305H and -305R) shows an upward gradient from the bedrock into the overlying alluvial deposits, evidence that flow occurs from the bedrock into the alluvial soils.

The data available for the interstitial sampling points along the toe of the Slag Pile in OU1 indicate discharge occurs from the slag and alluvial soils along the river bank into the river. During high river stages, the flow was observed to be reversed and the river banks are recharged. However, the data are relatively limited to a few sampling events, a limited time of the year, and only those low river stages when these locations are accessible.

3.4.3.4 Water Level Variation

Water levels have been measured in MWs and piezometers on a quarterly basis. Measured water levels in OU1 and OU2 are presented on Tables 3.2.3-2 and 3.3.3-2, respectively. Water levels were generally lower in late 2007 following a prolonged drought. Several MWs were measured as dry during those sampling rounds. In some MWs, water levels rose in subsequent readings as much as 8 to 10 ft. Water levels were low in late 2008, suggesting seasonal variation results in lower water levels in the dry winter months. Higher levels are generally measured in spring and late summer. Note however, that some MWs do not reflect a regular seasonal variation. The MWs in the plant area of OU1 do not appear to exhibit seasonal variation, likely due to the majority of the area being paved or occupied by buildings.

The water levels of the interstitial sampling points at the toe of the Slag Pile have been shown to respond rapidly to changes in the river stage. No long term water level trend is evident for these locations as they were installed in June 2009 and were measured four times between June and October 2009. Additionally, the points are inaccessible during high river stages.

3.4.3.5 Summary

WBZ1, which is evident in the shallower materials, exhibits a relatively high hydraulic conductivity as compared to WBZ2, although there is considerable variation among the materials comprising the WBZ1 hydrogeologic zone. WBZ1 appears to be recharged through infiltration of precipitation, and locally through infiltration from the ponds on OU1, discharge from the bedrock WBZ2, and intermittently along the river banks during high river stages. Groundwater discharge occurs from WBZ2 bedrock into the overlying deposits, from WBZ1 in the upland areas into the slag and alluvial deposits in the LVR valley, and from the slag and alluvial deposits in the LVR valley into the LVR.

Gradients appear to be relatively flat in WBZ1 in the upland areas with steeper gradients along the bluff slopes and within the alluvial deposits. Areas with steeper gradients will likely support faster groundwater flow rates. Groundwater flow appears to be toward the east and southeast in both WBZ1 and WBZ2.

Seasonal variation in groundwater levels is evident in many of the MWs installed site-wide. Higher water levels were observed during the spring and late summer periods and lower levels were evident during the winter periods. These changes in water levels can result in redirected gradients, particularly in the flatter gradient areas of the uplands.

4.0 NATURE AND EXTENT OF CONTAMINATION

The nature and extent of contamination was characterized and delineated at OU1 and OU2 of the Matthiessen and Hegeler Zinc Company Site. Analytical results presented in this RI report were validated, and Appendices G-4-1a for OU1 and S-8 for OU2 present the data validation reports for OU1 and OU2, respectively.

To present the analytical results and to evaluate the nature and extent of contamination, a screening metric was used for data comparison. This metric is based on risk assessment screening levels approved by the regulatory agencies presented in Attachment 4, Revision 1, of the “Technical Approach Consensus Document, Human Health and Ecological Risk Assessments” (Consensus Document) (Geosyntec and SulTRAC 2008). The term “screening levels” is a general term that refers to screening criteria used in the risk assessment only. Sections [7.0](#) and [8.0](#) of this RI report, the HHRA and ERA summaries, respectively, and the Risk Assessment Report Appendix (Appendices RA-1) describe and use the risk assessment screening levels. For the nature and extent of contamination evaluation in this section, the risk assessment screening levels from the Consensus Document have been modified and are referred to by their proper names (such as MCL) or as “SVs” (SV). All SVs are summarized in Table 4.0-1.

The SVs summarized below were used for the nature and extent of contamination evaluation for the various matrices sampled at both OUs.

- OU1 and OU2 soil, building material, and pile sample results were compared to the US EPA RRSL and IRSL for soils.
- OU1 and OU2 groundwater sample results were compared to the US EPA MCLs and US EPA Tap Water RSLs.
- OU2 surface water sample results were compared to the most conservative values from the following sources:
 - Illinois Water Quality Standards (IWQS) based on general use and the protection of human health
 - IEPA derived Water Quality Criteria for Human Health
 - National Recommended Water Quality Criteria (NRWQC) for ingestion of aquatic organisms

If a SV for surface water was not available from any of the sources listed above, the US EPA Tap Water RSLs were used.

- LVR (OU1) surface water sample results were compared to Ecological SVs, which were selected using the following order of priority:
 - IWQS for the protection of Aquatic Organisms (chronic standard)
 - IEPA Derived Water Quality Criteria for Aquatic Organisms (chronic)
 - NRWQC for Aquatic Life (freshwater, chronic)
 - US EPA Region 5 (2003b) ESLs for surface water
- OU1 sediment sample results were compared to Ecological SVs which were selected in the following order of priority:
 - Consensus-based Threshold Effects Concentration (TEC) or Probable Effect Concentration (PEC) (MacDonald et al. 2000)
 - US EPA Region 5 (2003b) ESLs for sediment
- OU1 and OU2 soil and building material TCLP sample results were compared to the regulatory levels at 40 CFR §261.24
- OU1 and OU2 soil SPLP sample results were compared to the regulatory levels at 40 CFR §261.24 and the US EPA groundwater MCLs. If groundwater MCLs were not available for a particular analyte, then the US EPA Tap Water RSLs were used

In December 2009, the US EPA RSLs and IRSLs were updated, the soil RSLs for chromium were revised, and the RSLs for thallium were removed. The update specified RSLs for speciated chromium (i.e., trivalent and hexavalent chromium). Since previous US EPA RSLs were for total chromium, only total chromium was measured during this RI. Since speciated chromium results are not available, the total chromium soil, slag, building material, and pile sample results were used and compared to the April 2009 US EPA RSL for total chromium. The revised December 2009 RSLs only include a MCL, and do not include soil, sediment, surface water, or tap water SVs for thallium. Therefore, the April 2009 US EPA RSLs were used for comparison to the thallium soil, slag, building material, pile, groundwater, and surface water sample results. The MCL listed in the December 2009 RSLs was used to evaluate thallium measured in groundwater samples.

Site-wide soil background total metals concentrations were established as described in Appendix RA-2 and Sections [4.1.2](#) and [4.2.2](#) for OU1 and OU2, respectively. These background concentrations were also used for comparison purposes as applicable in the following sections. The discussion is focused on COIs where measured background concentrations were greater than SVs for soils. Appendix RA-2 discusses statistical procedures relevant to the derivation of these background concentrations.

In the following sections, the terms “impact,” “impacts,” “impacted”, or “contaminated” media or areas refer to concentrations that exceed one or more of the SVs. As recognized in the Consensus Document, exceedances of SVs do not in themselves indicate that an unacceptable risk to human health or the environment exists. Rather, an exceedance merely indicates the need for further evaluation in the risk assessment. Thus, the terms “impact,” “contaminated”, and like terms must be understood in this context.

The following sections discuss the OU1 RI results ([Section 4.1](#)), OU2 RI results ([Section 4.2](#)), and the site-wide interpretation of RI results ([Section 4.3](#)).

4.1 OU1 INVESTIGATION AREAS AND ANALYTICAL RESULTS

A historical overview of the Carus and Matthiessen and Hegeler Zinc Company operations was presented in [Section 1.2.2](#) and the Technical Letter Report (Geosyntec 2006). See the Technical Letter Report for a detailed description of the potential sources of contamination at OU1. Further, note that certain data from OU1 were from samples collected in 1991 and 1993, by Geosyntec and IEPA. It was agreed in the Work Plan to include these data as a matter of completeness. The COIs present in the soil, metals primarily, are not typically subject to significant change over time, and these data were included to facilitate as complete a characterization of the Site as the available data could provide. Where groundwater data are provided from historical sampling, those data will be presented on a separate figure, recognizing that groundwater chemistry is more subject to change over time than is soil chemistry.

[Section 4.1.1](#) summarizes the OU1 investigation areas. [Section 4.1.2](#) summarizes the OU1 soil sampling results. [Section 4.1.3](#) summarizes the OU1 groundwater sampling results. [Section 4.1.4](#) summarizes the OU1 sediment and surface water sampling results. [Section 4.1.5](#) summarizes the vertical extent of impacts in OU1. [Section 4.1.6](#) summarizes the horizontal extent of impacts in OU1. [Section 4.1.7](#) summarizes the OU1 air sampling results.

4.1.1 OU1 Investigation Areas

For the purposes of the RI, OU1 was divided into three investigation areas as shown on Figures 4.1.1-1 and 4.1.1-2. These investigation areas are designated as follows:

- Plant Area
- Slag Pile Area
- LVR

Figure 4.1.1-1 is a map of all OU1 sampling areas and locations, including the sampling locations upstream and downstream of OU1 and OU2 along the LVR. Figure 4.1.1-2 is a detailed map of all OU1 sampling areas, including the groundwater, soil, surface water, and sediment sampling locations. The following sections describe each sampling area. The sampling procedures and analytical methods are described in detail in [Section 2](#). A summary of the analytical results and comparisons to SVs are included in the following sections.

4.1.1.1 Plant Area

The Plant Area is the present Carus Chemical Company manufacturing facility located at 1500 Eighth Street, LaSalle, Illinois, in the northwest quarter of Section 14 and in the northeast quarter of Section 15 in Township 33 North, Range 1 East of the Third Principal meridian in LaSalle County, Illinois. The Plant Area contains numerous buildings associated with the manufacturing process of potassium permanganate and other specialty chemicals.

Samples were collected from the Plant Area to investigate the potential impact to soil and groundwater; sediment and surface water samples were not applicable to the Plant Area. Samples were analyzed for the following:

- Metals
- Cyanide
- PCBs
- SVOCs
- VOCs
- Pesticides
- Other inorganic compounds (such as calcium or magnesium)

4.1.1.2 **Slag Pile**

The Slag Pile is located in the northwest quarter of Section 14 in Township 33 North (as referenced above), just east of the Plant Area. Based on historical records, the formation of the Slag Pile likely began in the early 1860s and was completed in the early 1960s.

Samples were collected from the Slag Pile Area to investigate the potential impact to soil, sediment, and groundwater. Sediment samples were collected from the holding pond. Surface water samples were not applicable to the Slag Pile. Samples were analyzed for the following:

- Metals
- Cyanide
- PCBs
- SVOCs
- VOCs
- Pesticides
- Other inorganic compounds

4.1.1.3 **Little Vermilion River**

The LVR runs along OU2 and the Slag Pile Area of OU1, is part of OU1, and serves as the eastern boundary of OU1 and OU2. The river generally runs from north to south toward its confluence with the Illinois River approximately one mile south of the Site.

Samples were collected from the LVR to investigate the potential impact to sediment and surface water; soil and groundwater samples were not applicable to the LVR. Samples were analyzed for the following:

- Metals
- Cyanide
- PCBs
- SVOCs
- VOCs
- Pesticides
- Other inorganic compounds

4.1.2 OU1 Soil Results

The following sections discuss the RI soil sampling results for OU1 for the Plant Area and the Slag Pile sampling areas. Table 4.1.2-1 is a summary of all shallow soil samples and Table 4.1.2-2 is a summary of deep soil samples collected from OU1. Listed in these summary tables are sampling locations, dates, depths, and analytical groups that were measured (Note that certain samples listed on Table 4.1.2-1 collected by IEPA have a depth designation of 0 ft bgs. This is the depth noted on the IEPA sample log, and that depth was included without editing.). A comprehensive listing of analytical data is included in Appendices G-4-1 through G-4-8. The data validation reports for these analyses are included in Appendix G-4-1a.

Figures 4.1.2-1 through 4.1.2-8 are maps of soil sampling locations within OU1 where the measured concentrations of COI type (i.e., metals, cyanide, VOCs, SVOCs, PCBs, or pesticides) were above SVs for soil samples collected from each sampling area. Blue circles indicate that measured concentrations were below analytical method detection limits. Green circles indicate that measured concentrations were above analytical method detection limits, but below RRSLS. Brown circles indicate the measured concentrations were above the BTVs but below the RRSLS for at least one COI, with the exception of arsenic, where the BTV is above the RRSL and IRSLS. For arsenic, an exceedance of the BTV is indicated by a red circle. Yellow circles indicate that measured concentrations were above RRSLS at that location for at least one COI. Red circles indicate that measured concentrations were above IRSLS at that location for at least one COI. Data boxes summarizing the measured COI concentrations that were above SVs for each location are also included.

BTVs are less than RRSLS and IRSLS for all metals, except arsenic and manganese. The BTV for arsenic is 10.7 mg/kg in shallow soils and 12.44 mg/kg in deep soils, both of which are greater than the RRSL, 0.39 mg/kg, and the IRSLS, 1.6 mg/kg. The BTV for manganese is 1,527 mg/kg in shallow soils and 2,726 mg/kg in deep soils, the deep soil BTV being greater than the RRSL, 1,800 mg/kg, but less than the IRSLS, 23,000 mg/kg. Therefore, arsenic and manganese soil results are described relative to RRSLS, IRSLS, and BTVs, and BTVs are not discussed for other metals.

4.1.2.1 Plant Area Soil Results

Both shallow and deep soil samples were collected and analyzed for metals, cyanide, SVOCs, VOCs, PCBs, pesticides, and other inorganic compounds from the Plant Area. Tables 4.1.2-1 and 4.1.2-2 list the

analyses performed on each soil sample. Samples collected within 2 ft bgs were classified as shallow soil samples. Samples collected at depths between 2 and 15 ft bgs were classified as deep soil samples.

Table 4.1.2-3 summarizes the analytical data for shallow soil samples collected from the Plant Area with concentrations above SVs. Table 4.1.2-4 summarizes the analytical data for deep soil samples collected from the Plant Area with concentrations above SVs. For each analyte, the tables list the number of samples with concentrations above RRSLs, the number of samples with concentrations above IRSLS, the total number of samples, and the range of concentrations. The analytes are grouped by type, and only analytes with at least one detected concentration above a SV are listed, or where the detection limit was greater than the SV.

Metals

Figure 4.1.2-1 is a map of Plant Area shallow soil sampling locations with metals concentrations above their respective SVs. Figure 4.1.2-2 is a map of Plant Area deep soil sampling locations with metals concentrations above their respective SVs.

Table 4.1.2-5 summarizes the Plant Area shallow soils metals concentrations. Table 4.1.2-6 summarizes the Plant Area deep soil metals concentrations. The concentrations of all analytes listed in Tables 4.1.2-5 and 4.1.2-6 were above the analytical method detection limits in at least one sample.

The metals concentrations most frequently measured above SVs in Plant Area shallow soil samples were arsenic and manganese. Arsenic concentrations in Plant Area shallow soil samples were above its RRSL and IRSLS in 14 of 15 soil samples (Table 4.1.2-3). The range of detected concentrations of arsenic in Plant Area shallow soils was 3.0 to 33.6 mg/kg (Table 4.1.2-3 and 4.1.2-5). However, the BTV for arsenic in shallow soil (10.7 mg/kg) was above the IRSLS (1.6 mg/kg). Only five of 15 samples were above the arsenic shallow soil BTV. The locations of those samples above the shallow soil BTV were in the southeastern part of the Plant Area (Figure 4.1.2-1).

Manganese concentrations were above its RRSL in 7 of 15 Plant Area shallow soil samples, and were above its IRSLS in 1 of 15 shallow soil samples (Table 4.1.2-3 and 4.1.2-5). These samples were primarily located on the eastern half of the Plant Area (Figure 4.1.2-1). The range of detected concentration of manganese was 231 to 118,000 mg/kg (Tables 4.1.2-3 and 4.1.2-5).

Other metals in Plant Area shallow soils with concentrations above SVs included iron, lead, mercury, and zinc (Tables 4.1.2-3, and Figure 4.1.2-1).

Iron concentrations were above its RRS� in 2 of 14 shallow soil samples (Table 4.1.2-3 and 4.1.2-5) (Note, iron was not measured in one of the samples from 1991). These samples were primarily located on the eastern half of the Plant Area (Figure 4.1.2-1). The range of iron concentrations was 3,990 to 160,000 mg/kg (Tables 4.1.2-3 and 4.1.2-5).

Lead concentrations were above its RRS� and IRS� in 2 of 15 shallow soil samples (Table 4.1.2-3 and 4.1.2-5). These samples were primarily located on the eastern half of the Plant Area (Figure 4.1.2-1). The range of lead concentrations was 2.8 to 3,660 mg/kg (Tables 4.1.2-3 and 4.1.2-5).

Mercury concentrations were above its RRS� in 1 of 15 shallow soil samples (Table 4.1.2-3 and 4.1.2-5). This sample was located on the eastern half of the Plant Area (Figure 4.1.2-1). The range of mercury concentrations was 0.020 to 8.6 mg/kg (Tables 4.1.2-3 and 4.1.2-5).

Zinc concentrations were above its RRS� in 1 of 15 shallow soil samples (Table 4.1.2-3 and 4.1.2-5). This sample was located on the eastern half of the Plant Area (Figure 4.1.2-1). The range of zinc concentrations was 14.1 to 26,500 mg/kg (Tables 4.1.2-3 and 4.1.2-5).

The metals with concentrations most frequently measured above SVs in Plant Area deep soil samples (2 to 15 ft bgs) were also arsenic and manganese. Arsenic concentrations in Plant Area deep soils were above its RRS� in 12 of 15 samples, and above IRS�s in 11 of 15 samples (Tables 4.1.3-4). The range of arsenic concentrations was 0.21 to 50.5 mg/kg (Tables 4.1.2-4 and 4.1.2-6). However, the BTV for arsenic in deep soil (12.44 mg/kg) was measured to be above the IRS� (1.6 mg/kg). Only 2 of 15 locations had arsenic concentrations above the deep soil BTV; these locations were near the center and along the far eastern edge of the Plant Area (Figure 4.1.2-2).

Manganese concentrations in Plant Area deep soil samples were above its RRS� and the deep soil BTV in 4 of 15 samples, and none exceeded the IRS� (Table 4.1.2-4). The locations of samples above the manganese RRS� were clustered toward the southeast part of the Plant Area (Figure 4.1.2-2). The range of manganese concentrations was 81 to 9,380 mg/kg (Tables 4.1.2-3 and 4.1.2-5).

Other metals with measured concentrations above SVs in Plant Area deep soil samples were cobalt and lead (Tables 4.1.2-4 and 4.1.2-6, and Figure 4.1.2-2).

Cobalt concentrations in Plant Area deep soil samples were above the RRS� in 1 of 15 samples, and none exceeded the IRS� (Table 4.1.2-4). The sample above the cobalt RRS� was collected from the center of

the Plant Area (Figure 4.1.2-2). The range of cobalt concentrations was 3.5 to 24.7 mg/kg (Tables 4.1.2-3 and 4.1.2-5).

Lead concentrations in Plant Area deep soil samples were above its RRS� in 1 of 15 samples, and none exceeded the IRS� (Table 4.1.2-4). The sample above the lead RRS� was collected from the eastern side of the Plant Area (Figure 4.1.2-2). The range of lead concentrations was 2.9 to 510 mg/kg (Tables 4.1.2-3 and 4.1.2-5).

Cyanide

Cyanide concentrations were below all of its SVs in all shallow and deep Plant Area soils (Table 4.1.2-5).

VOCs

Table 4.1.2-7 summarizes the Plant Area shallow soil VOC concentrations and Table 4.1.2-8 summarizes the Plant Area deep soil VOC concentrations. None of the measured concentrations of VOCs in Plant Area shallow or deep soils exceeded RRS�s or IRS�s for the detected analytes. Ten VOCs had measured concentrations above detection limits in shallow soil samples:

- 2-butanone (MEK)
- 2-hexanone
- 4-methyl-2-pentanone
- Acetone
- Carbon disulfide
- Cyclohexane,
- Dichloromethane (methylene chloride)
- Ethyl benzene
- Methylcyclohexane
- Toluene

Eight VOCs had measured concentrations above detection limits in deep soil samples:

- Acetone
- Benzene
- Cyclohexane
- Dichloromethane (methylene chloride)
- Ethyl benzene
- Methylcyclohexane
- Toluene
- Xylenes (unspecified)

The analytical results in Tables 4.1.2-7 and 4.1.2-8 show that measured concentrations of VOCs were below RRS�s or IRS�s at seven shallow locations and four deep locations.

SVOCs

Figure 4.1.2-3 is a map of Plant Area shallow soil sampling locations with SVOC concentrations above SVs. Table 4.1.2-9 summarizes the Plant Area shallow soil SVOC concentrations. Six of the analytes listed in Table 4.1.2-9 were measured at concentrations above detection limits in at least one sample.

The SVOC with concentrations most frequently measured above SVs in Plant Area shallow soils was benzo(a)pyrene. Benzo(a)pyrene concentrations in Plant Area shallow soils were above its IRSL in two of seven soil samples, and above its RRS� in three of seven soil samples (Tables 4.1.2-3 and 4.1.2-9). The detection limit of the analytical method for benzo(a)pyrene is above its IRSL for four other samples (Table 4.1.2-9). The locations of the samples with concentrations above SVs were spread across the center of the Site from the east to the west side of the Plant Area (Figure 4.1.2-3). The range of benzo(a)pyrene concentrations was 130 to 1,000 microgram per kilogram ($\mu\text{g}/\text{kg}$) (Tables 4.1.2-3 and 4.1.2-9).

Other SVOCs with concentrations above SVs in Plant Area shallow soils were benzo(a)anthracene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene (Tables 4.1.2-3 and 4.1.2-9, and Figure 4.1.2-3).

Benzo(a)anthracene concentrations in Plant Area shallow soils were above its RRS� in two of seven samples and none exceeded the IRSL (Table 4.1.2-3). The detection limit of the analytical method for benzo(a)anthracene was above its RRS� for four other samples. The locations of these samples were not concentrated in any particular area of the Plant Area (Figure 4.1.2-3). The range of benzo(a)anthracene concentrations was 110 to 740 mg/kg (Tables 4.1.2-3 and 4.1.2-9).

Benzo(b)fluoranthene concentrations in Plant Area shallow soils were above its RRS� in two of seven samples and none exceeded the IRSL (Table 4.1.2-3). The detection limit of the analytical method for benzo(b)fluoranthene is above its RRS� for three other samples (Table 4.1.2-9). The locations of these samples were spread across the Plant Area (Figure 4.1.2-3). The range of benzo(b)fluoranthene concentrations was 41.0 to 1,200 mg/kg (Tables 4.1.2-3 and 4.1.2-9).

Benzo(g,h,i)perylene concentrations in Plant Area shallow soils were above its RRS� in one of seven samples but none exceeded the IRSL (Table 4.1.2-3). The detection limit of the analytical method for benzo(g,h,i)perylene is above its RRS� for five other samples. The locations of these samples were spread across the Plant Area (Figure 4.1.2-3). The range of benzo(g,h,i)perylene concentrations was 64.0 to 760 mg/kg (Tables 4.1.2-3 and 4.1.2-9).

Dibenzo(a,h)anthracene concentrations in Plant Area shallow soils were above its RRSL in one of seven samples and none exceeded the IRSL (Table 4.1.2-3). The detection limit of the analytical method for dibenzo(a,h)anthracene is above its IRSL for six other samples (Table 4.1.2-9). The locations of these samples were spread across the Plant Area (Figure 4.1.2-3). The range of dibenzo(a,h)anthracene concentrations was 200 to less than 430 mg/kg (Tables 4.1.2-3 and 4.1.2-9).

Indeno(1,2,3-cd)pyrene concentrations in Plant Area shallow soils were above its RRSL in two of seven samples and none exceeded the IRSL (Table 4.1.2-3). The detection limit of the analytical method for indeno(1,2,3-cd)pyrene is above its RRSL for four other samples (Table 4.1.2-9). The locations of these samples were spread across the Plant Area (Figure 4.1.2-3). The range of indeno(1,2,3-cd)pyrene concentrations was less than 23 to 690 mg/kg (Tables 4.1.2-3 and 4.1.2-9).

Table 4.1.2-10 summarizes the SVOC analytical results for Plant Area deep soil samples. The analytical results show that concentrations of SVOCs were below RRSLs and IRSLs in two deep soil samples collected from seven ft bgs. The detected SVOCs were bis(2-ethylhexyl)phthalate and di-n-butylphthalate (Table 4.1.2-10).

PCBs

Figure 4.1.2-4 is a map of Plant Area shallow soil sampling locations with PCB concentrations above SVs. Table 4.1.2-11 summarizes the PCB analytical results for Plant Area shallow soils.

Two types of PCBs (Aroclor 1254 and 1260) were detected in four shallow soil samples. One sample (SSI-X102) had measured concentrations above the IRSL for the two Aroclors detected. The range of Aroclor 1254 concentrations was less than 38 to 2,800 microgram per kilogram ($\mu\text{g/kg}$), and the range of Aroclor 1260 concentrations was less than 38 to 1,100 $\mu\text{g/kg}$ (Tables 4.1.2-3 and 4.1.2-11). Location SSI-X102, which had the exceedances, is located in the center of the Plant Area (Figure 4.1.2-4). The sample was collected from the surface (0 ft bgs).

Table 4.1.2-12 summarizes the PCB analytical results for Plant Area deep soil samples. The table shows that detectable Aroclor 1254 concentrations in deep soil samples were observed at two locations, but they were below RRSLs or IRSLs.

Pesticides

Pesticides concentrations were below analytical method detection limits in all shallow soil samples collected from six locations. Pesticides concentrations were also below analytical method detection limits in all deep soil samples collected from two locations (Appendix G-4-5). The analytical method detection limits for each pesticide analyte were below the corresponding RRSLs and IRSLS.

Other Inorganic Compounds

Table 4.1.2-13 summarizes the analytical results for other inorganic compounds for Plant Area shallow soil samples and Table 4.1.2-14 summarizes the analytical results for other inorganic compounds for Plant Area deep soil samples. The inorganic compounds listed in Tables 4.1.2-13 and 4.1.2-14 did not have associated SVs; therefore these inorganic compounds were not considered COIs. The other inorganic compounds detected in shallow and deep soil samples in the Plant Area include the following:

- Calcium
- Magnesium
- Potassium
- Sodium
- Sulfate
- Sulfide

While these constituents are not considered contaminants at the Site, some of the constituents may have an impact on the fate and transport of other COIs. These considerations are discussed in [Section 5](#).

4.1.2.2 Slag Pile Area Soil Results

The analytical results for metals, cyanide, VOCs, SVOCs, PCBs, pesticides, and other inorganic compounds in Slag Pile Area soil samples are summarized below. Both shallow and deep soil samples were collected and analyzed. Shallow soil samples were collected within 2 ft bgs. Slag Pile Area deep soil samples were collected from depths ranging from 2 to 109 ft bgs.

Table 4.1.2-15 is a summary of the Slag Pile Area shallow soil sample analytical data. Table 4.1.2-16 is a summary of the Slag Pile Area deep soil sample analytical data. For each analyte, these tables list the number of samples with concentrations above RRSLs, the number of samples with concentrations above

IRSLs, the total number of samples, and the range of concentrations measured. The analytes are grouped by type and only analytes that were measured at concentrations above the SVs are listed.

Metals

Figure 4.1.2-5 is a map of Slag Pile Area shallow soil sampling locations for which metals concentrations were above SVs. Figure 4.1.2-6 is a map of Slag Pile Area deep soil sampling locations for which concentrations of metals were above SVs. Metals were detected at concentrations above RRSLs and IRSLs in numerous samples from the Slag Pile Area.

Table 4.1.2-17 summarizes the metals and cyanide analytical results for Slag Pile Area shallow soil samples. Table 4.1.2-18 summarizes the metals and cyanide analytical results for Slag Pile Area deep soil samples. All analytes listed in Tables 4.1.2-17 and 4.1.2-18 had concentrations above analytical method detection values in at least one sample.

The metals with concentrations most frequently above SVs in Slag Pile Area shallow soil samples were arsenic, lead, and manganese. The locations of these samples were not concentrated in one particular area of the Slag Pile Area (Figure 4.1.2-5).

Arsenic concentrations in Slag Pile Area shallow soils were above its RRSL and IRSL in all 17 samples, and above its shallow soil BTV in 16 of 17 soil samples (Table 4.1.2-15). The range of arsenic concentrations was 3.3 to 251 mg/kg (Tables 4.1.2-15 and 4.1.2-17).

Lead concentrations in Slag Pile Area shallow soils were above its RRSL in 11 of 17 samples and above its IRSL in eight of 17 samples (Table 4.1.2-15). The range of lead concentrations was 116 to 38,700 mg/kg (Tables 4.1.2-15 and 4.1.2-17).

Manganese concentrations in Slag Pile Area shallow soil samples were above its RRSL in 7 of 17 samples and above its IRSL in one of 17 samples (Table 4.1.2-15). The range of manganese concentrations was 287 to 123,000 mg/kg (Tables 4.1.2-15 and 4.1.2-17).

Other metals with measured concentrations above SVs in Plant Area shallow soils were cadmium, cobalt, copper, mercury, vanadium, and zinc (Tables 4.1.2-15 and 4.1.2-17, and Figure 4.1.2-5).

Cadmium concentrations in Slag Pile Area shallow soils were above its RRSL in 4 of 17 samples, and none were above its IRSL (Table 4.1.2-15). The range of cadmium concentrations was 4.3 to 181 mg/kg (Tables 4.1.2-15 and 4.1.2-17).

Cobalt concentrations in Slag Pile Area shallow soils were above its RRSL in 4 of 17 samples, and none were above its IRSL (Table 4.1.2-15). The range of cobalt concentrations was 2.8 to 273 mg/kg (Tables 4.1.2-15 and 4.1.2-17).

Copper concentrations in Slag Pile Area shallow soils were above its RRSL in 1 of 17 samples, and none were above its IRSL (Table 4.1.2-15). The range of copper concentrations was 44.5 to 4,340 mg/kg (Tables 4.1.2-15 and 4.1.2-17).

Mercury concentrations in Slag Pile Area shallow soils were above its RRSL in 2 of 15 samples, and none were above its IRSL (Table 4.1.2-15). The range of mercury concentrations was less than 0.074 to 18.5 mg/kg (Tables 4.1.2-15 and 4.1.2-17).

Vanadium concentrations in Slag Pile Area shallow soils were above its RRSL in 1 of 17 samples, and none were above its IRSL (Table 4.1.2-15). The range of vanadium concentrations was 7.6 to 899 mg/kg (Tables 4.1.2-15 and 4.1.2-17).

Zinc concentrations in Slag Pile Area shallow soils were above its RRSL in 5 of 17 samples, and none were above its IRSL (Table 4.1.2-15). The range of zinc concentrations was 1,830 to 79,900 mg/kg (Tables 4.1.2-15 and 4.1.2-17).

The metals most frequently measured above SVs in Slag Pile Area deep soil samples were arsenic, iron, lead, and manganese. The locations of these samples were not concentrated in one particular area of the Slag Pile Area (Figure 4.1.2-6).

Arsenic concentrations in Slag Pile Area deep soils were above its RRSL and IRSL for 20 of 21 samples (Table 4.1.2-16). These samples were from 11 borings. However, the deep soil BTV measured for arsenic (12.44 mg/kg) is above the IRSL. Arsenic concentrations were above the deep soil BTV in 10 of 21 samples. The range of arsenic concentrations was 0.19 to 117 mg/kg (Tables 4.1.2-16 and 4.1.2-18).

Iron concentrations in Slag Pile Area deep soils were above its RRSL in ten of 38 samples (Table 4.1.2-16). The range of iron concentrations was 5,240 to 209,000 mg/kg (Tables 4.1.2-16 and 4.1.2-18).

Lead concentrations were above its RRSL in ten of 38 Slag Pile Area deep soil samples and above IRSLS in seven of 38 samples (Table 4.1.2-16). The range of lead concentrations was 1.4 to 3,850 mg/kg (Tables 4.1.2-16 and 4.1.2-18).

Manganese concentrations were above its RRSL in ten of 38 Slag Pile Area deep soil samples, above its deep soil BTV in 7 of 38 samples, and above IRSLS in 1 of 38 samples (Table 4.1.2-16). The range of manganese concentrations was 23.6 to 40,600 mg/kg (Tables 4.1.2-16 and 4.1.2-18).

Other metals with concentrations above SVs in Slag Pile Area deep soils were antimony, cadmium, cobalt, mercury, and zinc (Tables 4.1.2-16 and 4.1.2-18, and Figure 4.1.2-6).

Antimony concentrations were above its RRSL in 2 of 21 Slag Pile Area deep soil samples, and none were above its IRSLS (Table 4.1.2-16). The range of antimony concentrations was less than 0.86 to 81.4 mg/kg (Tables 4.1.2-16 and 4.1.2-18).

Cadmium concentrations were above its RRSL in 6 of 38 Slag Pile Area deep soil samples, and none were above its IRSLS (Table 4.1.2-16). The range of cadmium concentrations was 0.70 to 521 mg/kg (Tables 4.1.2-16 and 4.1.2-18).

Cobalt concentrations were above its RRSL in 7 of 21 Slag Pile Area deep soil samples, and none were above its IRSLS (Table 4.1.2-16). The range of cobalt concentrations was 3.2 to 55.2 mg/kg (Tables 4.1.2-16 and 4.1.2-18).

Mercury concentrations were above its RRSL in 1 of 38 Slag Pile Area deep soil samples, and none were above its IRSLS (Table 4.1.2-16). The range of mercury concentrations was less than 0.0030 to 6.1 mg/kg (Tables 4.1.2-16 and 4.1.2-18).

Zinc concentrations were above its RRSL in 5 of 38 Slag Pile Area deep soil samples, and none were above its IRSLS (Table 4.1.2-16). The range of zinc concentrations was 63 to 170,000 mg/kg (Tables 4.1.2-16 and 4.1.2-18).

Cyanide

Cyanide concentrations were below all of its SVs in all shallow and deep Slag Pile Area soils (Table 4.1.2-18).

VOCs

Table 4.1.2-19 summarizes the VOC analytical results for Slag Pile Area shallow soil samples. Table 4.1.2-20 summarizes the VOC analytical results for Slag Pile Area deep soil samples. None of the measured concentrations of VOCs in Slag Pile shallow or deep soils exceeded RRSLs or IRSLS for the

detected analytes. Fourteen VOCs had measured concentrations above detection limits in Slag Pile Area shallow soils:

- 1, 1, 1-trichloroethane
- 2-butanone (MEK)
- Acetone
- Benzene
- Carbon disulfide
- Chloroform
- Cis/trans-1, 2-dichloroethene (DCE)
- Cis-1, 3-dichloropropene
- Dichloromethane (methylene chloride)
- Methyl acetate
- Methylcyclohexane
- Tetrachloroethene (PCE)
- Toluene
- Xylenes (unspecified)

Thirteen VOCs were measured at concentrations above detection limits in deep soil samples from the Slag Pile Area:

- 2-butanone (MEK)
- Acetone
- Benzene
- Carbon disulfide
- Cyclohexane
- Dichloromethane (methylene chloride)
- Ethyl benzene
- Isopropylbenzene
- M&p-xylene
- Methyl acetate
- Methylcyclohexane
- O-xylene
- Toluene

The analytical results in Tables 4.1.2-19 and 4.1.2-20 show that measured concentrations of VOCs were below their respective SVs at seven shallow locations and seven deep locations.

SVOCs

Figure 4.1.2-7 is a map of Slag Pile Area shallow soil sampling locations, and Figure 4.1.2-8 is a map of Slag Pile Area deep soil sampling locations with SVOC concentrations above their respective SVs. Table 4.1.2-21 summarizes the SVOC analytical results for Slag Pile Area shallow soils and Table 4.1.2-22 summarizes the SVOC analytical results for Slag Pile Area deep soils. All analytes listed in Tables 4.1.2-21 and 4.1.2-22 were detected at concentrations above their respective analytical detection limits in at least one sample, or SVs were greater than detection limits.

Shallow soils from two borings had SVOC concentrations above the SVs (ISA-X106 and MW-306S). Three borings had non-detectable concentrations, the detections were below the SVs, or the detection limits were above the SVs (MW-301H, SSI-X103, and SSI-X104). Shallow soils from two borings had

non-detections (ISA-X104 and ISA-X105, no detection limits given in raw data report from others). The locations of shallow soil samples with SVOC concentrations above SVs were not concentrated in one particular area of the Slag Pile (Figure 4.1.2-7). The SVOCs with concentrations above SVs in Slag Pile Area shallow soils were benzo(a)pyrene and hexachlorobenzene.

The benzo(a)pyrene concentration in Slag Pile Area shallow soils was above its RRS� in one of seven soil samples, and none were above its IRS� (Table 4.1.2-15). The detection limit for benzo(a)pyrene is above its IRS� for three other samples (MW-301H, SSI-X104, and SSI-X103). The benzo(a)pyrene concentration in the MW-306S sample was 96.0 µg/kg; however, other sample results were less than the analytical method detection limit of 380 µg/kg (Tables 4.1.2-15 and 4.1.2-21).

The hexachlorobenzene concentration in Slag Pile Area shallow soils was above its RRS� and IRS� in one of seven soil samples (Table 4.1.2-15). The detection limit for hexachlorobenzene is above its RRS� for four other samples (MW-301H, SSI-X104, SSI-X103, and MW-306S) (Table 4.1.3-21). The range of hexachlorobenzene concentrations was less than 380 to 7,300 µg/kg (Tables 4.1.3-15 and 4.1.3-21).

In the deep soil samples, four borings had detections above the SVOC SVs (SB-316, MW-303H, SB-307, and SB-308) and three borings had non-detectable concentrations (SB-302, MW-304S, and SB-309). The SVOCs with concentrations above SVs most frequently in Slag Pile Area deep soils were benzo(a)pyrene and dibenzo(a,h)anthracene. The benzo(a)pyrene concentration in Slag Pile Area deep soils was above its RRS� in four of seven samples and above its IRS� in one of those seven samples (Table 4.1.2-16). The benzo(a)pyrene analytical method detection limit is above its IRS� for three samples (SB-302, MW-304S, and SB-309) (Table 4.1.2-22 and Figure 4.1.2-8). The range of measured benzo(a)pyrene concentrations was up to 390 µg/kg (Tables 4.1.2-16 and 4.1.2-22). The samples with benzo(a)pyrene concentrations above SVs were from the central and southern portions of the Slag Pile, and collected from two to 90 ft bgs (Figure 4.1.2-8).

Dibenzo(a,h)anthracene concentrations in Slag Pile Area deep soils were above its RRS� in three of seven soil samples, and none were above its IRS� (Tables 4.1.2-16 and 4.1.2-22). The dibenzo(a,h)anthracene analytical method detection limit is above its IRS� for four other samples (SB-302, MW-304S, MW-303H, and SB-309) (Table 4.1.2-22 and Figure 4.1.2-8). The range of measured dibenzo(a,h)anthracene concentrations was up to 73.0 µg/kg (Tables 4.1.2-16 and 4.1.2-22). The samples with dibenzo(a,h)anthracene concentrations above SVs were from the southern end of the Slag Pile, and collected from two to 37 ft bgs (Figure 4.1.2-8).

Other SVOCs with concentrations above SVs in Slag Pile Area deep soils were benzo(a)anthracene, benzo(b)fluoranthene, benzo(g,h,i)perylene, and indeno(1,2,3-cd)pyrene (Tables 4.1.2-16 and 4.1.2-22, and Figure 4.1.2-8).

Benzo(a)anthracene concentrations in Slag Pile Area deep soils were above its RRSL in two of seven soil samples, and none were above its IRSL (Tables 4.1.2-16 and 4.1.2-22). The benzo(a)anthracene analytical method detection limit is above its RRSL for three other samples (SB-302, MW-304S, and SB-309) (Table 4.1.2-22 and Figure 4.1.2-8). The range of measured benzo(a)anthracene concentrations was up to 390 µg/kg (Tables 4.1.2-16 and 4.1.2-22).

Benzo(b)fluoranthene concentrations in Slag Pile Area deep soils were above its RRSL in two of seven soil samples, and none were above its IRSL (Tables 4.1.2-16 and 4.1.2-22). The benzo(b)fluoranthene analytical method detection limit is above its RRSL for three other samples (SB-302, MW-304S, and SB-309) (Table 4.1.2-22 and Figure 4.1.2-8). The range of measured benzo(b)fluoranthene concentrations was up to 360 µg/kg (Tables 4.1.2-16 and 4.1.2-22).

Benzo(g,h,i)perylene concentration in Slag Pile Area deep soils was above its RRSL in one of seven soil samples, and none were above its IRSL (Tables 4.1.2-16 and 4.1.2-22). The benzo(g,h,i)perylene analytical method detection limit is above its RRSL for three other samples (SB-302, MW-304S, and SB-309) (Table 4.1.2-22 and Figure 4.1.2-8). The range of measured benzo(g,h,i)perylene concentrations was up to 210 µg/kg (Tables 4.1.2-16 and 4.1.2-22).

Indeno(1,2,3-cd)pyrene concentration in Slag Pile Area deep soils was above its RRSL in one of seven soil samples, and none were above its IRSL (Tables 4.1.2-16 and 4.1.2-22). The indeno(1,2,3-cd)pyrene analytical method detection limit is above its RRSL for three other samples (SB-302, MW-304S, and SB-309) (Table 4.1.2-22 and Figure 4.1.2-8). The range of measured indeno(1,2,3-cd)pyrene concentrations was up to 190 µg/kg (Tables 4.1.2-16 and 4.1.2-22).

PCBs

Table 4.1.2-23 summarizes the PCB analytical results for Slag Pile Area shallow soils. Table 4.1.2-23 shows that Aroclor 1254 and Aroclor 1260 concentrations in shallow soil samples were measured, but were below their respective RRSLs and IRSLS at the ten locations sampled. There were no PCBs detected in Slag Pile Area deep soils.

Pesticides

Table 4.1.2-24 summarizes the pesticide analytical results for Slag Pile Area shallow soils. Measureable concentrations of 13 pesticides were observed in shallow soil samples collected from ten locations. However, all pesticide concentrations were below their respective RRSLs or IRSRLs (Table 4.1.2-24). There were no pesticides detected in Slag Pile Area deep soil samples.

Other Inorganic Compounds

Table 4.1.2-25 summarizes the analytical results for other inorganic compounds for Slag Pile Area shallow soils. Table 4.1.2-26 summarizes the analytical results for other inorganic compounds for Slag Pile Area deep soils. The inorganic compounds listed in Tables 4.1.2-25 and 4.1.2-26 did not have associated SVs; therefore these inorganic compounds are not considered COIs. The other inorganic compounds detected in Slag Pile Area shallow soils included the following (Table 4.1.2-25):

- Calcium
- Magnesium
- Potassium
- Sodium
- Sulfate

The other inorganic compounds detected in Slag Pile Area deep soils included the following (Table 4.1.2-26):

- Bicarbonate
- Calcium
- Carbonate
- Magnesium
- Potassium
- Sodium
- Sulfate
- Sulfide

While these constituents are not considered contaminants at the Site, some of the constituents may have an impact on the fate and transport of other COIs. These considerations are discussed in [Section 5](#).

4.1.3 OU1 Groundwater Results

The following sections discuss the RI groundwater sampling results for the Plant and Slag Pile Areas. Table 4.1.3-1 is a summary of the analyses performed on all groundwater samples collected from OU1. Total and dissolved analyses were performed on the samples in accordance with the methods detailed in the US EPA-approved Work Plan and FSP. Listed in the summary table are wells (locations), sample dates, and analytes that were measured. A comprehensive listing of groundwater analytical data is

included in Appendices G-4-9 through G-4-14. It should be noted that some of the groundwater data are from the early 1990s and may not reflect current conditions. These data are presented on separate figures. The usefulness for different purposes (risk assessment, remedial alternatives analysis, etc.) will be addressed on a case-by-case basis.

Figures 4.1.3-1a through 4.1.3-6b are maps of MW locations where the groundwater concentration of at least one analyte within a COI type (i.e., metals, cyanide, VOCs, SVOCs, PCBs, or pesticides) was above its corresponding SV. Blue circles with crosses indicate that measured concentrations were below analytical method detection limits. Green circles with crosses indicate that measured concentrations were above analytical method detection limits, but below Tap Water RSLs or MCLs. Yellow circles with crosses indicate that measured concentrations were above Tap Water RSLs or MCLs at that well for at least one COI. Data boxes summarizing the measured COI concentrations that were above SVs for each location are also included. Data boxes include the highest value for each COI, regardless of date. As a result, the exceedances may not represent a single date of sampling.

COI exceedances in WBZ1 groundwater consisted of the following metals:

- | | | |
|-------------|--------------------|-------------|
| • Aluminum | • Cobalt | • Manganese |
| • Arsenic | • Copper | • Mercury |
| • Barium | • Chromium (total) | • Nickel |
| • Beryllium | • Iron | • Vanadium |
| • Cadmium | • Lead | • Zinc |

COI exceedances in WBZ1 groundwater consisted of the following VOCs and SVOC:

- | VOCs | SVOCs |
|-----------------------|--------------------------------|
| • 1,2-dichloroethane | • (bis(2-ethylhexyl)phthalate) |
| • vinyl chloride (VC) | |

The COI exceedances in WBZ2 groundwater were limited to the following metals:

- | | |
|------------|-------------|
| • Aluminum | • Iron |
| • Arsenic | • Lead |
| • Cadmium | • Manganese |
| • Cobalt | • Mercury |

4.1.3.1 Plant Area Groundwater Results

The analytical results for metals, cyanide, VOCs, SVOCs, PCBs, pesticides, and other inorganic compounds in groundwater samples from the Plant Area are summarized below. Samples were analyzed from six different wells in the Plant Area, with multiple samples at different times analyzed from some of these wells. Data on some wells date back to as early as 1991. Several wells installed in the northwestern and central areas of the Plant Area (MW311R and MW317R) were not able to be sampled due to insufficient recharge of water into those wells after pre-sampling well development.

Table 4.1.3-2 is a summary of the analytical data for Plant Area groundwater samples with concentrations above SVs. Listed are the number of samples and wells with concentrations above Tap Water RSLs, the number of samples and wells with concentrations of COIs above MCLs, the total number of samples and wells, and the range of concentrations. The analytes are grouped by type, and only analytes that were measured above SVs are listed.

Metals

Figure 4.1.3-1a is a map of Plant Area wells with dissolved metals concentrations above SVs based on historical data collected from 1991 to 1994. Figure 4.1.3-1b is a map of Plant Area wells with dissolved metals concentrations above SVs based on data collected after 1994. Figure 4.1.3-2a is a map of Plant Area wells with total metals concentrations above SVs based on historical data collected from 1991 to 1994. Figure 4.1.3-2b is a map of Plant Area wells with total metals concentrations above SVs based on data collected after 1994.

Table 4.1.3-3 summarizes the groundwater metals analytical results for Plant Area samples. All analytes listed in Table 4.1.3-3 were detected at concentrations above analytical method detection limits in at least one sample, except thallium (Appendix G-4-9). The results are for 25 samples from 6 different wells, and include dissolved and total metals analyses from these wells.

Similar to the soil sampling results, the metals with total or dissolved concentrations most frequently above SVs in Plant Area groundwater samples were arsenic, cadmium, cobalt, manganese, and zinc. The locations of these samples were not concentrated in one particular area of the Plant Area (Figures 4.1.3-1a, 4.1.3-1b, 4.1.3-2a, and 4.1.3-2b).

Total and dissolved groundwater arsenic concentrations in the Plant Area were above its Tap Water RSL in 18 of 25 groundwater samples (6 of 6 wells), and above its MCL in 1 of 25 groundwater samples (1 of

6 wells) (Table 4.1.3-2). The range of arsenic concentrations was less than 0.52 to 21.1 micrograms per liter ($\mu\text{g/L}$) (Tables 4.1.3-2 and 4.1.3-3).

Total and dissolved groundwater cadmium concentrations in the Plant Area were above its Tap Water RSL in 10 of 25 groundwater samples (5 of 6 wells), and above its MCL in 13 of 25 groundwater samples (5 of 6 wells) (Table 4.1.3-2). The range of cadmium concentrations was less than 0.21 to 82.4 $\mu\text{g/L}$ (Tables 4.1.3-2 and 4.1.3-3).

Total and dissolved groundwater cobalt concentrations in the Plant Area were above its Tap Water RSL in 10 of 22 samples (5 of 6 wells) (Table 4.1.3-2). The range of cobalt concentrations was less than 5.0 to 74 $\mu\text{g/L}$ (Tables 4.1.3-2 and 4.1.3-3).

Total and dissolved groundwater manganese concentrations in the Plant Area were above its Tap Water RSL in 16 of 22 samples (6 of 6 wells) (Table 4.1.3-2). The range of manganese concentrations was 1.1 to 14,400 $\mu\text{g/L}$ (Tables 4.1.3-2 and 4.1.3-3).

Total and dissolved groundwater zinc concentrations in the Plant Area were above its Tap Water RSL in 6 of 22 samples (2 of 6 wells) (Table 4.1.3-2). The range of zinc concentrations was 6.4 to 17,100 $\mu\text{g/L}$ (Tables 4.1.3-2 and 4.1.3-3).

Other metals with measured concentrations above SVs in Plant Area groundwater samples were aluminum, barium, beryllium, chromium (total), iron, lead, mercury, and vanadium (Tables 4.1.3-2 and 4.1.3-3, and Figures 4.1.3-1a, 4.1.3-1b, 4.1.3-2a, and 4.1.3-2b).

Total and dissolved groundwater aluminum concentrations in the Plant Area were above its Tap Water RSL in 3 of 22 samples (3 of 6 wells) (Table 4.1.3-2). The range of aluminum concentrations was less than 100 to 123,000 $\mu\text{g/L}$ (Tables 4.1.3-2 and 4.1.3-3).

Total and dissolved barium groundwater concentrations in the Plant Area were above its MCL in 2 of 25 samples (1 of 6 wells) (Table 4.1.3-2). The range of barium concentrations was less than 100 to 2,530 $\mu\text{g/L}$ (Tables 4.1.3-2 and 4.1.3-3).

Total and dissolved groundwater beryllium concentrations in the Plant Area were above its MCL in 2 of 22 samples (2 of 6 wells) (Table 4.1.3-2). The range of beryllium concentrations was less than 0.48 to 13.0 $\mu\text{g/L}$ (Tables 4.1.3-2 and 4.1.3-3).

Total and dissolved groundwater chromium concentrations in the Plant Area were above its MCL in 4 of 25 samples (3 of 6 wells) (Table 4.1.3-2). The range of total chromium concentrations was less than 1.1 to 417 µg/L (Tables 4.1.3-2 and 4.1.3-3).

Total and dissolved groundwater iron concentrations in the Plant Area were above its Tap Water RSL in 3 of 22 samples (3 of 6 wells) (Table 4.1.3-2). The range of iron concentrations was less than 21.6 to 208,000 µg/L (Tables 4.1.3-2 and 4.1.3-3).

Total and dissolved groundwater lead concentrations in the Plant Area were above its MCL in 7 of 25 samples (4 of 6 wells) (Table 4.1.3-2). The range of lead concentrations was less than 0.60 to 2,180 µg/L (Tables 4.1.3-2 and 4.1.3-3).

Total and dissolved groundwater mercury concentrations in the Plant Area were above its MCL in 1 of 25 groundwater samples (1 of 6 wells), and above its Tap Water RSL in 2 of 25 samples (2 of 6 wells) (Table 4.1.3-2). The range of mercury concentrations was less than 0.028 to 12.9 µg/L (Tables 4.1.3-2 and 4.1.3-3).

Total and dissolved groundwater vanadium concentrations in the Plant Area were above its Tap Water RSL in 1 of 22 samples (1 of 6 wells) (Table 4.1.3-2). The range of vanadium concentrations was less than 1.0 to 253 µg/L (Tables 4.1.3-2 and 4.1.3-3).

Cyanide

Cyanide concentrations were below its SV in all Plant Area groundwater samples (Table 4.1.3-3).

VOCs

Figure 4.1.3-3a is a map of Plant Area groundwater sampling locations with VOC concentrations above SVs based on data collected from 1991 to 1994. Figure 4.1.3-3b is a map of Plant Area groundwater sampling locations with VOC concentrations above SVs based on data collected after 1994. Only one location exhibited VOC concentrations above the Tap Water RSL (G-103) (Figure 4.1.3-3b). VOC concentrations in all historical samples were below SVs (Figure 4.1.3-3a).

Table 4.1.3-4 summarizes the Plant Area groundwater VOC analytical results. Four analytes listed in Table 4.1.3-4 were measured at concentrations above their respective analytical method detection limits

in at least one sample. These VOCs were 1,2-dichloroethane, dichloromethane (methylene chloride), trichloroethene (TCE), and VC.

The 1, 2-dichloroethane concentration in Plant Area groundwater samples was above its Tap Water RSL in one of eight groundwater samples (one of five wells) (Table 4.1.3-2). The 1,2-dichloroethane analytical method detection limit was above its Tap Water RSL for seven samples, and above its MCL for four samples.

The VC concentration in Plant Area groundwater samples was above its Tap Water RSL in one of eight groundwater samples (one of five wells) (Table 4.1.3-2). The VC analytical method detection limit was above its Tap Water RSL for seven samples, and above its MCL for four samples. The location of the single Plant Area sample with concentrations above the VC Tap Water RSL was along the northeast margin of the Plant Area in well G-103 (Figure 4.1.3-3b).

Dichloromethane (methylene chloride) and TCE were detected above their analytical method detection limit in at least one sample, but none of the measured concentrations exceeded their respective Tap Water RSLs or MCLs (Table 4.1.3-4).

SVOCs

Figure 4.1.3-4a is a map of Plant Area wells with groundwater SVOC concentrations above SVs based on historical data collected from 1991 to 1994. Figure 4.1.3-4b is a map of Plant Area wells with groundwater SVOC concentrations above SVs based on data collected after 1994. Table 4.1.3-5 summarizes the Plant Area groundwater SVOC analytical results. One analyte (bis[2-ethylhexyl]phthalate) was detected at a concentration above detection limits in one historical sample (Table 4.1.3-5 and Figure 4.1.3-4a). The bis(2-ethylhexyl)phthalate concentration was above its Tap Water RSL and above its MCL in one of nine groundwater samples (one of five wells) (Table 4.1.3-2). The analytical method detection limits for several SVOCs (including bis[2-ethylhexyl]phthalate) were above both SVs (Appendix G-4-11). The groundwater sample with bis(2-ethylhexyl)phthalate concentrations above SVs was collected near the eastern border of the Plant Area and Slag Pile Area (see well G-106 on Figure 4.1.3-4a). The maximum concentration of bis(2-ethylhexyl)phthalate was 7 µg/L (Table 4.1.3-5).

PCBs

There were no detectable concentrations of PCBs in groundwater samples collected from five wells in the Plant Area; all groundwater sample results were below analytical method detection limits (Appendix G-4-12).

Pesticides

There were no detectable concentrations of pesticides in groundwater samples collected from five wells in the Plant Area; all groundwater sample results were below analytical method detection limits (Appendix G-4-13).

Other Inorganic Compounds

Table 4.1.3-6 summarizes the analytical results for other inorganic compounds for Plant Area groundwater samples. The inorganic compounds listed in Table 4.1.3-6 do not have associated SVs; therefore these inorganic compounds are not considered COIs. The other inorganic compounds detected in Plant Area groundwater samples include the following (Table 4.1.3-6):

- Bicarbonate
- Calcium
- Carbonate
- Magnesium
- Potassium
- Sodium
- Sulfate

While these constituents are not considered contaminants at the Site, some of the constituents may have an impact on the fate and transport of other COIs. These considerations are discussed in [Section 5](#).

4.1.3.2 Slag Pile Groundwater Results

The analytical results for metals, cyanide, VOCs, SVOCs, and other inorganic compounds in Slag Pile Area groundwater samples are summarized below. Groundwater samples from the Slag Pile Area were not analyzed for pesticides and PCBs. Samples were analyzed from 16 different wells in the Slag Pile Area, with multiple samples at different times analyzed from some of these wells. Data on some wells date back to as early as 1992.

Table 4.1.3-7 is a summary of the analytical data for Slag Pile Area groundwater samples with concentrations above SVs. Listed are the number of samples and wells with concentrations above Tap

Water RSLs, the number of samples and wells with concentrations of COIs above MCLs, the total number of samples and wells, and the range of concentrations. The analytes are grouped by type, and only analytes that were measured above SVs are listed.

Metals

Figure 4.1.3-5a is a map of Slag Pile Area wells with dissolved metals concentrations above SVs based on historical data collected from 1991 to 1994. Figure 4.1.3-5b is a map of Slag Pile Area wells with dissolved metals concentrations above SVs based on data collected after 1994. Figure 4.1.3-6a is a map of Slag Pile Area wells with total metals concentrations above SVs based on historical data collected from 1991 to 1994. Figure 4.1.3-6b is a map of Slag Pile Area wells with total metals concentrations above SVs based on data collected after 1994. Table 4.1.3-8 summarizes the metals analytical results for groundwater samples from the Slag Pile Area. All analytes listed in Table 4.1.3-8 were detected at concentrations above analytical method detection limits in at least one sample.

The metals most frequently measured above SVs in Slag Pile Area groundwater samples were manganese, arsenic, cadmium, and cobalt. The locations of these samples were not concentrated in one particular area of the Slag Pile Area (Figures 4.1.3-5a, 4.1.3-5b, 4.1.3-6a, and 4.1.3-6b).

Total and dissolved manganese concentrations in Slag Pile Area groundwater samples were above Tap Water RSLs for 34 of 37 groundwater samples (16 of 16 wells) (Table 4.1.3-7). There is no MCL specified for manganese. The range of manganese concentrations was 106 to 25,300 µg/L (Tables 4.1.3-7 and 4.1.3-8).

Total and dissolved arsenic concentrations were above Tap Water RSLs in 22 of 27 groundwater samples (10 of 16 wells measured), and above MCLs in 6 of 27 groundwater samples (3 of 16 wells measured) (Table 4.1.3-7). The range of arsenic concentrations was less than 1.0 to 57.2 µg/L (Tables 4.1.3-7 and 4.1.3-8).

Total and dissolved cadmium concentrations were above its Tap Water RSL in 6 of 39 groundwater samples (5 of 16 wells measured), and above its MCL in 15 of 39 groundwater samples (8 of 16 wells measured) (Table 4.1.3-7). The range of cadmium concentrations was less than 0.33 to 2,220 µg/L (Tables 4.1.3-7 and 4.1.3-8).

Total and dissolved cobalt concentrations were above Tap Water RSLs in 14 of 24 groundwater samples (7 of 16 wells measured) (Table 4.1.3-7). The range of cobalt concentrations was less than 5.0 to 124 µg/L (Tables 4.1.3-7 and 4.1.3-8).

Other metals with concentrations above SVs in Slag Pile Area groundwater samples were cadmium, copper, iron, lead, mercury, nickel, and zinc (Tables 4.1.3-7 and 4.1.3-8, and Figures 4.1.3-5a, 4.1.3-5b, 4.1.3-6a, and 4.1.3-6b).

Total and dissolved copper concentrations were above its Tap Water RSL in 1 of 24 groundwater samples (1 of 16 wells measured), and above its MCL in 1 of 24 groundwater samples (1 of 16 wells measured) (Table 4.1.3-7). The range of copper concentrations was less than 1.0 to 3,120 µg/L (Tables 4.1.3-7 and 4.1.3-8).

Total and dissolved iron concentrations were above its Tap Water RSL in 5 of 37 groundwater samples (2 of 16 wells measured) (Table 4.1.3-7). There is no MCL specified for iron. The range of iron concentrations was less than 50.0 to 137,000 µg/L (Tables 4.1.3-7 and 4.1.3-8).

Total and dissolved lead concentrations were above its MCL in 10 of 39 groundwater samples (5 of 16 wells measured) (Table 4.1.3-7). The range of lead concentrations was less than 0.26 to 303 µg/L (Tables 4.1.3-7 and 4.1.3-8).

Total and dissolved mercury concentrations were above its Tap Water RSL in 1 of 39 groundwater samples (1 of 16 wells measured), and above its MCL in 1 of 39 groundwater samples (1 of 16 wells measured) (Table 4.1.3-7). The range of mercury concentrations was less than 0.019 to 2.1 µg/L (Tables 4.1.3-7 and 4.1.3-8).

Total and dissolved nickel concentrations were above its Tap Water RSL in 1 of 37 groundwater samples (1 of 16 wells measured) (Table 4.1.3-7). There is no MCL specified for nickel. The range of nickel concentrations was less than 20.0 to 1,090 µg/L (Tables 4.1.3-7 and 4.1.3-8).

Total and dissolved zinc concentrations were above its Tap Water RSL in 8 of 37 groundwater samples (6 of 16 wells measured) (Table 4.1.3-7). There is no MCL specified for zinc. The range of zinc concentrations was less than 20.0 to 831,000 µg/L (Tables 4.1.3-7 and 4.1.3-8).

Cyanide

Cyanide concentrations were below its SV in all Slag Pile Area groundwater samples (Appendix G-4-9).

VOCs

There were no detectable concentrations of VOCs in groundwater samples collected from two wells in the Slag Pile Area; all groundwater sample results were below method detection limits and the method detection limits were below Tap Water RSLs and MCLs for all VOCs (Appendix G-4-10). Additional samples were planned for VOC analysis from the Slag Pile; however, several wells did not have sufficient water to allow for sampling and analysis.

SVOCs

Table 4.1.3-9 summarizes the SVOC analytical results for groundwater samples from the Slag Pile Area. All groundwater sample results were below analytical method detection limits, except di-n-butylphthalate, which was measured in a 1993 groundwater sample from MW-1 (Table 4.1.3-9). For a number of analytes, the method detection limit was above the Tap Water RSL (Appendix G-4-11). Additional samples were planned for SVOC analysis from the Slag Pile; however, several wells did not have sufficient water to allow for sampling and analysis.

PCBs

PCBs were not measured in Slag Pile Area groundwater samples.

Pesticides

Pesticides were not measured in Slag Pile Area groundwater samples.

Other Inorganic Compounds

Table 4.1.3-10 summarizes the analytical results for other inorganic compounds for Slag Pile Area groundwater samples. The inorganic compounds listed in Table 4.1.3-10 do not have associated SVs; therefore these inorganic compounds are not considered COIs. These other inorganic compounds detected in groundwater samples in the Slag Pile Area include the following (Table 4.1.3-10):

- Bicarbonate
- Calcium
- Carbonate
- Magnesium

- Potassium
- Sodium
- Sulfate
- Sulfide

While these constituents are not considered contaminants at the Site, some of the constituents may have an impact on the fate and transport of other COIs. These considerations are discussed in [Section 5](#).

4.1.4 OU1 Sediment and Surface Water Results

The following sections discuss the RI sediment and surface water sampling results for OU1. Table 4.1.4-1 is a summary of the analyses performed on all sediment samples collected from OU1. Table 4.1.4-2 is a summary of the analyses performed on all surface water samples collected from OU1. Listed in these summary tables are sampling locations, sample dates, and analytical groups that were measured. A comprehensive list of analytical data is included in Appendices G-4-15 through G-4-29.

Figures 4.1.4-1 through 4.1.4-11 are maps of locations where the measured concentrations of COIs (i.e., metals, cyanide, VOCs, SVOCs, PCBs, or pesticides) were above SVs for sediment and surface water samples collected from each sampling area. Blue symbols indicate that measured concentrations were below method detection limits. Green symbols indicate that measured concentrations were detected but were below SVs at that location. Yellow symbols indicate that measured concentrations were above SVs at that location (Sediment ESVs for sediment samples, surface water [SW] ESV for surface water samples). Data boxes summarizing the measured COI concentrations that were above SVs for each location are also included on the figures.

4.1.4.1 Slag Pile Sediment Results

The analytical results for metals, cyanide, VOCs, SVOCs, PCBs, pesticides, and other inorganic compounds in Slag Pile Area sediment samples are summarized below. The sediment samples are from the holding pond at the south end of the Slag Pile Area and from an area of ephemeral standing water near the center of the west side of the Slag Pile adjacent to a seep originating on OU2, sample UL-215 (Figure 4.1.4-1). Note that the sediment samples collected from the holding pond were collected in the early 1990s as part of the IEPA site Assessments. These data were included as a matter of data completeness. The Slag Pile Area holding pond is part of the operating Carus Plant, which is not part of the CERCLA RI. The US EPA-approved Work Plan and FSP did not include any sampling of the Carus operating facilities.

Table 4.1.4-3 is a summary of the analytical data for Slag Pile Area sediment samples with concentrations were above SVs. The numbers of samples are listed where measured concentrations were above Sediment ESVs for each analyte, the total number of samples, and the range of concentrations. The analytes are grouped by type, and only analytes that were measured above SVs are listed.

Metals

Figure 4.1.4-1 is a map of Slag Pile Area sediment sampling locations with metals concentrations above SVs. Table 4.1.4-4 summarizes the metals analytical results for Slag Pile Area sediment samples. All analytes listed in Table 4.1.4-4 were detected at concentrations above detection limits in at least one sample.

The metals most frequently measured above SVs in Slag Pile Area sediments were arsenic, cadmium, chromium (total), copper, lead, mercury, nickel, and zinc. The locations of these samples were within the holding pond, with the exception of UL-215 (Figure 4.1.4-1). There was also one sample where the concentration of silver was measured above the SV.

Arsenic concentrations were above the SV in all three samples where it was measured (Table 4.1.4-3). These samples were collected from the holding pond within the Slag Pile Area and at UL-215 (Figure 4.1.4-1). The range of arsenic concentrations was 31.5 to 42.8 mg/kg (Table 4.1.4-3).

Cadmium concentrations were above the SV in all seven samples collected from six different sampling locations (two samples collected from Pond Line 1) (Table 4.1.4-3). These samples were collected from the holding pond within the Slag Pile Area and UL-215 (Figure 4.1.4-1). The range of cadmium concentrations was 2.9 to 99.3 mg/kg.

Chromium (total) concentrations were above the SV in five of seven samples collected from four different sampling locations (two samples collected from Pond Line 1) (Table 4.1.4-3). These samples were collected from the holding pond within the Slag Pile Area (Figure 4.1.4-1). The range of chromium concentrations was 16.8 to 280 mg/kg.

Copper concentrations were above the SV in all three samples analyzed for copper collected from the Slag Pile Area (Table 4.1.4-3). These samples were collected from the holding pond within the Slag Pile Area and UL-215 (Figure 4.1.4-1). Copper was not analyzed in four of the sediment samples from the Slag Pile Area. The range of copper concentrations was 185 to 550 mg/kg.

Lead concentrations were above the SV in all seven samples collected from the Slag Pile Area (Table 4.1.4-3). These samples were collected from the holding pond within the Slag Pile Area and UL-215 (Figure 4.1.4-1). The range of lead concentrations was 69.8 to 1,810 mg/kg.

Mercury concentrations were above the SV in all seven samples collected from the Slag Pile Area (Table 4.1.4-3). These samples were collected from the holding pond within the Slag Pile Area and UL-215 (Figure 4.1.4-1). The range of concentrations was 0.27 to 1.9 mg/kg.

Nickel concentrations were above the SV in all seven samples collected from the Slag Pile Area (Table 4.1.4-3). These samples were collected from the holding pond within the Slag Pile Area and UL-215 (Figure 4.1.4-1). The range of nickel concentrations was 50.4 to 737 mg/kg.

Silver concentrations were above the SV in one of three samples collected from the Slag Pile Area (Table 4.1.4-3). This sample was collected from UL-215 (Figure 4.1.4-1). Silver was not analyzed in four samples from the Slag Pile Area. The silver concentrations ranged from less than 3.8 to 15.2 mg/kg.

Zinc concentrations were above the SV in all seven samples collected from the Slag Pile Area (Table 4.1.4-3). These samples were collected from the holding pond within the Slag Pile Area and UL-215 (Figure 4.1.4-1). The zinc concentrations ranged from 513 to 87,700 mg/kg.

Cyanide

Cyanide concentrations were below its SV in all Slag Pile Area sediments (Appendix G-4-15). Cyanide detections in LVR sediments and surface water are discussed in [Section 4.1.4.2](#).

VOCs

Figure 4.1.4-2 is a map of Slag Pile Area sediment sampling locations with VOC concentrations above SVs. Table 4.1.4-5 summarizes the Slag Pile Area sediment VOC analytical results. Table 4.1.4-5 shows that concentrations of acetone were above its SV in two of three sediment samples from the Slag Pile Area. The range of acetone concentrations was 3.2 to 410 µg/kg. Carbon disulfide was also detected below its SV in one of three Slag Pile Area sediment samples (see SSI-X206 in Figure 4.1.4-2 and Table 4.1.4-5). The carbon disulfide concentrations were less than 30.0 µg/kg (Table 4.1.4-5).

SVOCs

Figure 4.1.4-3 is a map of Slag Pile Area sediment sampling locations with SVOC concentrations above SVs. Table 4.1.4-6 summarizes the Slag Pile Area sediment SVOC analytical results. All analytes listed in Table 4.1.4-6 were detected at concentrations above analytical method detection limits in at least one sample, or their respective SVs were above their analytical method detection limits.

SVOC concentrations were above their respective SVs in three of seven sediment sampling locations in the Slag Pile Area. Fourteen different SVOCs had measured concentrations above their respective SVs in one sample (UL-215), nine in another (SSI-X206), and one in the third sample (SSI-X205). It should be noted that in some of the analyses, the analytical method detection limit for the compound was above the SV for that compound. The SVOCs with measured concentrations above SVs in Slag Pile Area sediment samples included the following (Tables 4.1.4-3 and 4.1.4-6, and Figure 4.1.4-3):

- Acenaphthene
- Acenaphthylene
- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Bis(2-ethylhexyl)phthalate
- Carbazole
- Chrysene
- Dibenzo(a,h)anthracene
- Fluoranthene
- Indeno(1,2,3-cd)pyrene
- Phenanthrene
- Pyrene

Acenaphthene concentrations were above the SV in one of seven Slag Pile Area sediment samples (see UL-215 in Figure 4.1.4-3 and Table 4.1.4-3). The concentrations ranged from less than 18.0 to 160 µg/kg.

Acenaphthylene concentrations were above the SV in one of seven Slag Pile Area sediment samples (Table 4.1.4-6). This sediment sample was collected from UL-215 (Figure 4.1.4-3). The concentrations ranged from less than 10.0 to 1,400 µg/kg.

Anthracene concentrations were above the SV in two of seven Slag Pile Area sediment samples (Table 4.1.4-6). These sediment samples were collected from the holding pond and from UL-215 (Figure 4.1.4-3). The concentrations ranged from less than 6.6 to 1,800 µg/kg.

Benzo(a)anthracene concentrations were above the SV in two of seven Slag Pile Area sediment samples (Table 4.1.4-6). These sediment samples were collected from the holding pond and from UL-215 (Figure 4.1.4-3). The concentrations ranged from less than 0.13 to 6,700 µg/kg.

Benzo(a)pyrene concentrations were above the SV in two of seven Slag Pile Area sediment samples (Table 4.1.4-6). These sediment samples were collected from the holding pond and from UL-215 (Figure 4.1.4-3). The concentrations ranged from less than 0.23 to 6,700 µg/kg.

The benzo(g,h,i)perylene concentration was above the SV in one of seven Slag Pile Area sediment samples (Table 4.1.4-6). This sediment sample was collected from UL-215 (Figure 4.1.4-3). The concentrations ranged from less than 0.76 to 4,400 µg/kg.

Benzo(k)fluoranthene concentrations were above the SV in two of seven Slag Pile Area sediment samples (Table 4.1.4-6). These sediment samples were collected from the holding pond and from UL-215 (Figure 4.1.4-3). The concentrations ranged from less than 0.17 to 5,300 µg/kg.

Bis(2-ethylhexyl)phthalate concentrations were above the SV in two of three Slag Pile Area sediment samples (Table 4.1.4-6). These sediment samples were collected from the holding pond (Figure 4.1.4-3). Bis(2-ethylhexyl)phthalate was not measured in four samples from the pond sediment. The concentrations ranged from 460 to 580 µg/kg. The concentration of sample UL-215 was less than 2,900 µg/kg.

Carbazole concentration was above the SV in one of three Slag Pile Area sediment samples (Table 4.1.4-6). This sediment sample was collected from UL-215 (Figure 4.1.4-3). Carbazole was not measured in four of the sediment samples from the pond. The concentrations ranged from below the analytical method detection limit (less than 1,000 µg/kg) to 470 µg/kg.

Chrysene concentrations were above the SV in two of seven Slag Pile Area sediment samples (Table 4.1.4-6). These sediment samples were collected from the holding pond and from UL-215 (Figure 4.1.4-3). The concentrations ranged from less than 1.5 to 7,000 µg/kg.

The dibenzo(a,h)anthracene concentration was above the SV in one of seven Slag Pile Area sediment samples (Table 4.1.4-6). This sediment sample was collected from UL-215 (Figure 4.1.4-3). The concentrations ranged from less than 0.30 to 1,100 µg/kg.

Fluoranthene concentrations were above the SV in two of seven Slag Pile Area sediment samples (Table 4.1.4-6). These sediment samples were collected from the holding pond and from UL-215 (Figure 4.1.4-3). The concentrations ranged from less than 2.1 to 14,000 µg/kg.

The indeno(1,2,3-cd)pyrene concentration was above the SV in one of seven Slag Pile Area sediment samples (Table 4.1.4-6). This sediment sample was collected from UL-215 (Figure 4.1.4-3). The concentrations ranged from less than 0.43 to 3,700 µg/kg.

Phenanthrene concentrations were above the SV in two of seven Slag Pile Area sediment samples (Table 4.1.4-6). These sediment samples were collected from the holding pond and from UL-215 (Figure 4.1.4-3). The concentrations ranged from less than 6.4 to 6,000 µg/kg.

Pyrene concentrations were above the SV in two of seven Slag Pile Area sediment samples (Table 4.1.4-6). These sediment samples were collected from the holding pond and from UL-215 (Figure 4.1.4-3). The concentrations ranged from less than 2.7 to 14,000 µg/kg.

PCBs

Figure 4.1.4-4 is a map of Slag Pile Area sediment sampling locations with PCB concentrations above SVs. Table 4.1.4-7 summarizes the Slag Pile Area sediment PCB analytical results. Aroclor 1254 and Aroclor 1260 were detected at concentrations above their respective screening values. The Aroclor 1254 concentration in a sample collected from SSI-X206 in the holding pond was 2,900 µg/kg, which is above the SV (Figure 4.1.4-4 and Table 4.1.4-7). It should also be noted that the analytical method detection limit for Aroclor 1254 is above the SV for two other samples.

The Aroclor 1260 concentration in a sample collected from UL-215 was 1,900 µg/kg, which is above the SV (Figure 4.1.4-4 and Table 4.1.4-7). It should also be noted that the analytical method detection limit for Aroclor 1260 is above the SV for two other samples. No other PCBs were detected in sediment samples from the Slag Pile Area.

Pesticides

There were no detectable concentrations of pesticides in sediment samples collected from three locations; all sample results were below analytical method detection limits (Appendix G-4-19).

Other Inorganic Compounds

Table 4.1.4-8 summarizes the analytical results for other inorganic compounds for Slag Pile Area sediment samples. The inorganic compounds listed in Table 4.1.4-8 do not have associated SVs; therefore these inorganic compounds are not considered COIs. The other inorganic compounds detected in Slag Pile Area sediment samples include the following (Table 4.1.4-8):

- Bicarbonate
- Calcium
- Carbonate
- Magnesium
- Potassium
- Sodium
- Sulfate
- Sulfide

While these constituents are not considered contaminants at the Site, some of the constituents may have an impact on the fate and transport of other COIs. These considerations are discussed in [Section 5](#).

4.1.4.2 LVR Sediment and Surface Water Results

The analytical results for metals, cyanide, VOC, SVOC, PCB, pesticides, and other inorganic compounds in sediment and surface water samples from the LVR are summarized below. The results of samples of the CSO and ASO surface water discharges and the associated sediments potentially impacted by those discharges are described in this section because of their proximity to and potential to impact the LVR even though those features are within OU2. For ease of description, as used in this section, references to the LVR sediment and surface water samples should be understood to include samples of the CSO and ASO surface water and sediments.

Table 4.1.4-9 is a summary of the analytical data for LVR sediment samples and Table 4.1.4-10 is a summary of the analytical data for LVR surface water samples with concentrations above SVs. Listed are the number of samples with concentrations above SVs, the total number of samples for each analyte, the total number of sampling locations, and the range of concentrations measured. The analytes are grouped by type, and only analytes where measured concentrations were above SVs are listed.

Analyses of the LVR surface water included both total and dissolved metals. The analyses were in accordance with the US EPA-approved Work Plan and FSP. Total and dissolved analyses were conducted in order to facilitate assessment of the COIs transported in solution versus the material present as suspended sediment in the surface water.

Metals

Figure 4.1.4-5 is a map of LVR sediment sampling locations with metals concentrations above SVs.

Table 4.1.4-11 summarizes the metals analytical results for LVR sediment samples. All analytes listed in Table 4.1.4-11 were detected at concentrations above their respective analytical method detection limits in at least one sample.

The metals with concentrations most frequently measured above SVs in LVR sediment samples were cadmium, copper, silver, and zinc. The locations of these samples were spread along the LVR bordering the Slag Pile Area and OU2 (Figure 4.1.4-5). The distribution of samples with concentrations above SVs extended from north of the Slag Pile to south of the Site.

Figure 4.1.4-6 is a map of LVR surface water sampling locations with dissolved metals concentrations above SVs, and Figure 4.1.4-7 is a map of LVR surface water sampling locations with total metals concentrations above SVs. Duplicate analyses for split samples were conducted as a part of the quality control; however only the higher concentrations are shown in Figures 4.1.4-6 and 4.1.4-7. Table 4.1.4-12 summarizes the total and dissolved metals analytical results for LVR surface water samples. All analytes listed in Table 4.1.4-12 were detected at concentrations above analytical method detection limits in at least one sample.

The metals most frequently measured above SVs in LVR surface water samples were the following:

- Aluminum
- Cadmium
- Copper
- Lead
- Nickel
- Selenium
- Zinc

These exceedances occurred in both total and dissolved sample analyses. The majority of the samples with concentrations above SVs and typically the highest concentrations were measured in samples from the ASO and CSO.

The metals results for all LVR sediment and surface water samples are discussed in alphabetical order below.

No ESV has been established for aluminum in sediments. Aluminum concentrations were above its SV in 28 of 67 surface water samples (16 of 17 sampling locations), including three reference sampling locations upstream of the Site (see LVR-214, LVR-213, and LVR-409 in Figure 4.1.4-7). The aluminum samples with concentrations above SVs did not appear to be concentrated in any location (Figure 4.1.4-7). The range of aluminum concentrations was less than 14.9 to 5,050 µg/L.

Arsenic concentrations were above its SV in 12 of 49 LVR sediment samples (11 of 35 sampling locations) (Table 4.1.4-9). These sediment samples were collected near or downstream of the Slag Pile, except LVR-214, which is a background sample upstream of the Site (Figure 4.1.4-5). The range of sediment arsenic concentrations was 2.2 to 276 mg/kg (Table 4.1.4-9).

Arsenic concentrations in all LVR surface water samples were below its SV (Table 4.1.4-12).

Cadmium concentrations were above its SV in 48 of 52 LVR sediment samples (34 of 38 sampling locations) (Table 4.1.4-9), including three reference sampling locations upstream of the Site (see LVR-214, LVR-213, and QuarryBridge-07B in Figure 4.1.4-5). The range of concentrations was less than 0.72 to 46.5 mg/kg (Table 4.1.4-9). The cadmium samples with concentrations above SVs did not appear to be concentrated in any location (Figure 4.1.4-5).

Cadmium concentrations were above its SV in 24 of 71 LVR surface water samples (4 of 20 sampling locations) (Table 4.1.4-10). Two of the four sampling locations with cadmium concentrations above the SV were at the ASO and CSO (Figures 4.1.4-6 and 4.1.4-7). The other two locations were downstream of the ASO and CSO (Figure 4.1.4-7). The range of concentrations was less than 0.11 to 317 µg/L (Table 4.1.4-10).

Chromium concentrations in all LVR sediment samples were below its SV (Table 4.1.4-11).

Chromium concentrations were above its SV in 1 of 71 LVR surface water samples (1 of 20 sampling locations, LVR-408, Figure 4.1.4-7) (Table 4.1.4-10). The range of concentrations was less than 1.8 to 23.5 µg/L (Table 4.1.4-10).

The cobalt concentration was above its SV in 1 of 49 LVR sediment samples (1 of 35 sampling locations, LVR-405, Figure 4.1.4-5) (Table 4.1.4-9). The range of concentrations was 3.5 to 182 mg/kg (Table 4.1.4-9).

Cobalt concentrations in all LVR surface water samples were below its SV (Table 4.1.4-12).

Copper concentrations were above its SV in 23 of 49 LVR sediment samples (16 of 35 sampling locations) (Table 4.1.4-9). The sampling locations with copper concentrations above SVs were near and downstream of the ASO, and along and downstream of the Slag Pile (Figure 4.1.4-5). The range of concentrations was 5.0 to 3,320 mg/kg (Table 4.1.4-9).

Copper concentrations were above its SV in 21 of 67 LVR surface water samples (2 of 17 sampling locations) (Table 4.1.4-10). The sampling locations with copper concentrations above SVs were at the ASO and CSO (Figures 4.1.4-6 and 4.1.4-7). The range of concentrations was less than 5.0 to 129 µg/L (Table 4.1.4-10).

No ESV has been established for iron in sediments. Iron concentrations were above its SV in 7 of 71 LVR surface water samples (6 of 20 sampling locations) (Table 4.1.4-10). The sampling locations with iron concentrations above SVs were in the LVR along OU2, except two locations (Section_Line_DP, which is near the north side of the Slag Pile, and Quarry Bridge, which is a reference sampling location upstream of the Site) (Figure 4.1.4-7). The range of concentrations was less than 100 to 3,540 µg/L (Table 4.1.4-10).

Lead concentrations were above its SV in 21 of 52 LVR sediment samples (16 of 38 sampling locations) (Table 4.1.4-9). These sediment samples were collected near or downstream of the ASO and CSO, or near or downstream of the Slag Pile, except QuarryBridge-07B, which is a reference sampling location upstream of the Site (Figure 4.1.4-5). The range of concentrations was 3.9 to 1,050 mg/kg (Table 4.1.4-9).

Lead concentrations were above its SV in 15 of 71 LVR surface water samples (1 of 20 sampling locations, ASO-411, Figures 4.1.4-6 and 4.1.4-7) (Table 4.1.4-10). The range of concentrations was less than 0.13 to 91.0 µg/L (Table 4.1.4-10).

Mercury concentrations were above its SV in 5 of 48 LVR sediment samples (5 of 37 sampling locations) (Table 4.1.4-9). The analytical method detection limit was greater than the SV for 16 sediment samples from the LVR. With the exception of QuarryBridge-07B, the sediment samples with concentrations above SVs were collected near or downstream of the ASO and CSO, or near or downstream of the Slag Pile (Figure 4.1.4-5). The range of concentrations was 0.0060 to 0.53 mg/kg (Table 4.1.4-9).

Mercury concentrations in all LVR surface water samples were below its SV (Table 4.1.4-12).

Nickel concentrations were above its SV in 20 of 52 LVR sediment samples (17 of 38 sampling locations) (Table 4.1.4-9). These sediment samples were from various locations along the LVR, including QuarryBridge-07B, which is a reference sampling location upstream of the Site (Figure 4.1.4-5). The range of concentrations was 5.6 to 22,000 mg/kg (Table 4.1.4-9).

Nickel concentrations were above its SV in 28 of 71 LVR surface water samples (8 of 20 sampling locations) (Table 4.1.4-10). The sampling locations with nickel concentrations above SVs were located throughout the LVR (Figure 4.1.4-7). The range of concentrations was less than 10.0 to 75.2 µg/L (Table 4.1.4-10).

No ESV has been established for selenium in sediments. Selenium concentrations were above its SV in 12 of 67 LVR surface water samples (1 of 17 sampling locations, ASO-411, Figure 4.1.4-7) (Table 4.1.4-10). The range of concentrations was less than 0.56 to 13.2 µg/L (Table 4.1.4-10).

Silver concentrations were above its SV in 22 of 49 LVR sediment samples (13 of 35 sampling locations) (Table 4.1.4-9). These sediment samples were from various locations along the LVR, including LVR-214, which is a reference sampling location upstream of the Site (Figure 4.1.4-5). The range of concentrations was 0.18 to 46.4 mg/kg (Table 4.1.4-9).

Silver concentrations were above its SV in 4 of 67 LVR surface water samples (3 of 17 sampling locations) (Table 4.1.4-10). The sampling locations with silver concentrations above SVs were located at the ASO (ASO-411), and along the Slag Pile (LVR-405 and LVR-404, Figure 4.1.4-7). The range of concentrations was less than 0.74 to 1.0 µg/L (Table 4.1.4-10).

Zinc concentrations were above its SV in 41 of 52 LVR sediment samples (29 of 38 sampling locations) (Table 4.1.4-9). The sampling locations with zinc concentrations above SVs were located throughout the LVR, including LVR-214 and QuarryBridge-07B, which are reference sampling locations upstream of the Site (Figure 4.1.4-5). The range of concentrations was 0.16 to 49,100 mg/kg (Table 4.1.4-9).

Zinc concentrations were above its SV in 61 of 71 LVR surface water samples (13 of 20 sampling locations) (Table 4.1.4-10). The sampling locations with zinc concentrations above SVs were located throughout the LVR, including QuarryBridge-07B, which is a reference sampling location upstream of the Site (Figures 4.1.4-6 and 4.1.4-7). The range of concentrations was less than 20.0 to 69,200 µg/L (Table 4.1.4-10).

Cyanide

Cyanide concentrations were above its SV in 2 of 16 sediment samples (two of 15 sampling locations) (Table 4.1.4-9). The samples with concentrations above SVs were located just downstream of the ASO and CSO (location SSI-X202, Figure 4.1.4-5) and just downstream of the Slag Pile (location SSI-X203, Figure 4.1.4-5). These cyanide detections are from samples collected in 1991. Subsequent samples in these areas have not replicated these results.

Cyanide concentrations were above surface water ecological screening values (SW ESV) in duplicate samples from one location (Section Line DP), and in one sample from a reference sampling location upstream of the Site (QuarryBridge-07B)(Figure 4.1.4-5). Cyanide was also measured below analytical detection limits in three other samples (5th St. Bridge, LVR-205, and LVR-209), but the detection limit was above the SW ESV (Table 4.1.4-12).

VOCs

Figure 4.1.4-8 is a map of LVR sediment sampling locations with VOC concentrations above SVs. Table 4.1.4-13 summarizes the VOC analytical results for sediment samples from the LVR. Table 4.1.4-14 summarizes the VOC analytical results for LVR surface water samples. Detectable concentrations of 16 VOCs were measured in sediment samples collected from 13 locations. The detected VOCs included the following (Table 4.1.4-13):

- 1,1,1-trichloroethane
- 2-butanone (MEK)
- Acetone
- Benzene
- Carbon disulfide
- Chloroform
- Cis/trans-1,2-DCE
- Cyclohexane
- Dichloromethane (methylene chloride)
- Ethyl benzene
- M&p-xylene
- Methyl acetate
- Methylcyclohexane
- Toluene
- TCE
- Xylenes (unspecified)

The measured concentration of 2-butanone was above the sediment SV in 1 of 16 sediment samples collected from 15 sampling locations. Note that this sampling location was LVR-213, a reference

sampling location upstream of the Site (Figure 4.1.4-8). The measured concentrations of 2-butanone ranged from 2.9 to 66 µg/kg.

Acetone was measured at concentrations above the sediment SV in 10 of 16 sediment samples (9 of 16 locations) (Table 4.1.4-9). The sampling locations with acetone concentrations above SVs were located throughout the LVR, including LVR-214 and LVR-213, which are reference sampling locations upstream of the Site (Figure 4.1.4-8). Acetone concentrations ranged from 7.0 to 240 µg/kg. The concentrations of all other VOCs in sediment samples were below their respective SVs (Table 4.1.4-13).

Detectable concentration of acetone was measured in three LVR surface water samples and were below the SV. No other VOCs were detected in LVR surface water samples (Table 4.1.4-14).

SVOCs

Figure 4.1.4-9 is a map of LVR sediment sampling locations with SVOC concentrations above SVs. Table 4.1.4-15 summarizes the SVOC analytical results for LVR sediment samples. All analytes listed in Table 4.1.4-15 were detected at concentrations above analytical method detection limits in at least one sample, or SVs were above analytical method detection limits.

LVR sediment samples had detectable SVOC concentrations of 12 different compounds including the following:

- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Bis(2-ethylhexyl)phthalate
- Chrysene
- Fluoranthene
- Indeno(1,2,3-cd)pyrene
- Phenanthrene
- Pyrene

Seven of these SVOCs had concentrations above their respective SVs, including the following:

- Benzo(a)anthracene
- Benzo(a)pyrene
- Bis(2-ethylhexyl)phthalate
- Chrysene
- Fluoranthene
- Phenanthrene
- Pyrene

The samples with SVOC concentrations above SVs were limited to 5 of the 16 locations sampled. SVOC concentrations were above analytical method detection limits in 7 of the 16 locations samples. These locations were distributed along the reach of the LVR sampled, including LVR-213 (reference sampling location), and did not appear concentrated in any one location (Tables 4.1.4-9 and 4.1.4-15, and Figure 4.1.4-9).

There were no detectable SVOC concentrations measured in surface water samples collected from four locations. However, a number of the analytical detection limits were above the SVs (Appendix G-4-26).

PCBs

Figure 4.1.4-10 is a map of LVR sediment sampling locations with concentrations of PCBs above SVs. Table 4.1.4-16 summarizes the PCB analytical results for LVR sediment samples.

Three PCB Aroclors were detected in LVR sediment samples including PCB-1242 (Aroclor 1242), PCB-1254 (Aroclor 1254), and PCB-1260 (Aroclor 1260). Aroclor 1242 concentrations were above SVs in 2 of 16 sediment samples (2 of 14 sampling locations), and concentrations ranged from 38.0 to 810 µg/kg (Table 4.1.4-9). Aroclor 1254 concentrations were above SVs in 5 of 16 sediment samples (5 of 14 sampling locations), and concentrations ranged from 32.0 to 820 µg/kg. Aroclor 1260 concentrations were above SVs in 1 of 16 sediment samples (one of 14 sampling locations), and concentrations ranged from 12 to 190 µg/kg. The samples with PCB concentrations above SVs were collected in 1991 and 1993 from sampling locations ISA-X202, ISA-X203, ISA-X204, SSI-X201, and SSI-X204. These locations range from upstream of the ASO tributary confluence with the LVR to the downstream end of the Slag Pile adjacent to the holding pond (Figure 4.1.4-10).

There were no detectable PCB concentrations measured in surface water samples collected from four locations. However, the analytical detection limits were above the SVs (Appendix G-4-18).

Pesticides

Figure 4.1.4-11 is a map of LVR sediment sampling locations with pesticides concentrations above SVs. Table 4.1.4-17 summarizes the pesticide analytical results for LVR sediment samples. Detectable concentrations of ten pesticides were measured in sediment samples, including the following (Table 4.1.4-17):

- 4,4'-DDD
- 4,4'-DDE

- 4,4'-DDT
- Alpha-chlordane
- Delta-BHC
- Dieldrin
- Endrin
- Endrin aldehyde
- Endrin ketone
- Gamma-chlordane

Concentrations were above SVs for seven of these pesticides, including the following (Table 4.1.4-17):

- 4,4'-DDD
- 4,4'-DDT
- Alpha-chlordane
- Dieldrin
- Endrin
- Endrin aldehyde
- Gamma-chlordane

Concentrations of 4,4'-DDD were above its SV in 1 of 19 sediment samples (1 of 18 sampling locations), and concentrations ranged from less than 3.8 to 9.7 µg/kg.

Concentrations of 4,4'-DDT were above its SV in 1 of 19 sediment samples (1 of 18 sampling locations), and concentrations ranged from less than 3.8 to 9.2 µg/kg.

Concentrations of alpha-chlordane were above its SV in 2 of 19 sediment samples (2 of 18 sampling locations), and concentrations ranged from less than 2.0 to 17.0 µg/kg.

Concentrations of dieldrin were above its SV in 3 of 19 sediment samples (3 of 18 sampling locations), and concentrations ranged from less than 3.8 to 17.0 µg/kg.

Concentrations of endrin were above its SV in 4 of 19 sediment samples (4 of 18 sampling locations), and concentrations ranged from less than 3.8 to 67.0 µg/kg.

Concentrations of endrin aldehyde were above its SV in 1 of 19 sediment samples (1 of 18 sampling locations), and concentrations ranged from less than 3.8 to 9.9 µg/kg.

Concentrations of gamma-chlordane were above its SV in 1 of 19 sediment samples (1 of 18 sampling locations), and concentrations ranged from less than 2.0 to 5.1 µg/kg.

Measured concentrations of pesticides in LVR sediments above SVs came solely from samples collected in 1993. Samples collected in 1991 and 2007 did not detect pesticides above analytical method detection limits (Table 4.1.4-17).

There were no detectable concentrations of pesticides in surface water samples collected from five locations. However, some of the analytical detection limits are above the SVs (Appendix G-4-28).

Other Inorganic Compounds

Table 4.1.4-18 summarizes the analytical results for other inorganic compounds for LVR sediment samples. Table 4.1.4-19 summarizes the analytical results for other inorganic compounds for LVR surface water samples. The inorganic compounds listed in Tables 4.1.4-18 and 4.1.4-19 do not have associated SVs; therefore these inorganic compounds are not considered COIs. The other inorganic compounds detected in sediment samples in the LVR included the following (Table 4.1.4-18):

- Calcium
- Magnesium
- Potassium
- Sodium
- Sulfate
- Sulfide

The other inorganic compounds detected in LVR surface water samples included the following (Table 4.1.4-19):

- Bicarbonate
- Calcium
- Carbonate
- Magnesium
- Potassium
- Sodium
- Sulfate
- TSS

While these constituents are not considered contaminants at the Site, some of the constituents may have an impact on the fate and transport of other COIs. These considerations are discussed in [Section 5](#).

4.1.5 Vertical Extent of Contamination in Soil and Groundwater at OU1

This section discusses the vertical extent of contamination in soil and groundwater at OU1. Since soil and groundwater samples were collected at various depths, and sediment and surface water samples were collected at non-variable depths, the discussion of this section is focused on soil and groundwater sampling results.

Since metals were prevalent throughout OU1, cross sections of the soil and groundwater metals results were developed to illustrate and evaluate the vertical extent of metals impacts at OU1. The vertical extent of impacts in soil and groundwater for all other COIs are discussed qualitatively. Cross sections of the soil and groundwater results were not developed for other COIs.

4.1.5.1 Vertical Extent of Metal Contamination in Soil and Groundwater

This section discusses the vertical extent of metals impacts, generally, in soil and groundwater at OU1 and also includes specific discussion of the vertical extent of impacts for the predominant metals found in OU1 soil and groundwater samples: arsenic, lead, manganese, and zinc.

Figure 4.1.5-1 shows the OU1 boundaries, geologic cross-sections, groundwater MWs, and soil borings. Cross sections illustrating the COI distribution are indicated by the dashed black and white lines. The A to A' cross section runs from south to north through the Slag Pile Area. The B to B' cross section runs from west to east through the Plant and Slag Pile Areas. The C to C' cross section runs from west to east north of the B to B' cross section, and through the Plant and Slag Pile Areas. Figures 4.1.5-2 through 4.1.5-4 show the concentrations of metals within cross sections A to A', B to B', and C to C', respectively. Data boxes show the location, sample depth, geologic material, and the measured concentrations for metals present above the RRSLs, IRSLS, or BTVs in the case of arsenic and manganese. The cross sections also provide a color-coded description of the lithologic materials in the soil borings within each cross section (see [Section 3](#) for a more detailed description of the Site geology). The approximate elevation of the LVR is projected onto the cross sections as a blue line. Water levels in individual wells are not shown, in that some wells and borings are projected onto the cross sections. This projection would result in water levels not being correlated between borings and give the impression of multiple water levels. Water levels in individual wells on OU1 are indicated on Figures 3.2.3-2 through 3.2.3-5.

Figure 4.1.5-2 shows that measured metals concentrations were above their respective SVs and BTVs in soil samples collected from various depths across the Slag Pile Area. Metals concentrations were above their respective SVs in samples collected from surface fill, slag, and unconsolidated native media. The results for one soil sample collected from bedrock (P-22) had metals concentrations below their respective SVs.

Figure 4.1.5-3 shows that measured metals concentrations were above RRSLs in soil samples collected from various depths from the Plant Area and across to the Slag Pile Area. Plant Area soil samples show that some metals concentrations were above RRSLs in surface fill samples (see samples west of SB-315 in Figure 4.1.5-3). Figure 4.1.5-3 also shows the slope of the Slag Pile towards the LVR. The number of different metals with concentrations above the RRSLs in surface fill generally increases toward the east (along Slag Pile side slope). This increase in exceedances can likely be attributed to increasing amounts and thickness of slag waste to the east. To the west where slag deposits are thinner or absent, arsenic is

the predominant constituent above RRSLS. The IRSLS for arsenic is substantially below the arsenic BTV and relatively few samples exceed the BTV. In addition to arsenic, to the east in the slag and fill material, the following COIs were detected once or more frequently at concentrations above their respective BTV or their respective RRSLS (Figure 4.1.5-3):

- Antimony
- Cobalt
- Iron
- Lead
- Manganese
- Mercury

Figure 4.1.5-4 shows that metals concentrations were below BTVs in Plant Area soil samples collected from surface fill (SB-311, SB-312, C-8, and C-5), and above their respective SVs in soil samples collected at various depths from slag (ISA-X104, P-21, SSI-X103, and MW-305H). The results for one soil sample collected from bedrock (P-22) had metals concentrations below their respective SVs. Concentrations of arsenic in surface slag are higher than the measured concentrations in surface fill (Figure 4.1.5-4). Analytical results for the bedrock samples suggest that the elevated metals concentrations are within the overlying geologic layers (Figures 4.1.5-2 through 4.1.5-4).

Cross sections that show the vertical distribution of metal COIs in soil through the Slag Pile and the Plant Area are shown in Figures 4.1.5-5 through 4.1.5-12. Groundwater data for these constituents are also presented to illustrate the distribution of metals detected above the IRSLSs for locations where both solid and aqueous data are available.

Vertical Extent of Arsenic Contamination

Figure 4.1.5-5 summarizes soil and groundwater arsenic data along the north to south cross section that runs through the Slag Pile (transect A to A'). With the exception of soil borings from SB-309 and MW-306S, soil arsenic concentrations decrease with depth from the surface fill to the base of the slag with the majority of arsenic concentrations greater than 100 mg/kg associated with near surface fill or shallow slag. Groundwater arsenic concentrations are consistently less than the 10 µg/L MCL. Figure 4.1.5-6 shows the soil and groundwater arsenic data from the west to east cross section through the Plant Area (transect B to B'). Along the B to B' transect, soil arsenic concentrations vary with the highest arsenic concentration reported for a shallow sample of slag (SB-308, 0 to 1 ft bgs, 122 mg/kg). Groundwater results for wells screened in surface fill, slag, bedrock, and rubble indicate that arsenic concentrations were below the MCL with little variability (groundwater arsenic concentrations for wells shown in Figure 4.1.5-6 ranged from 1.3 to 9.0 µg/L). These data suggest that arsenic has limited mobility in fill, slag, and unconsolidated native media in the Carus Plant Area.

Vertical Extent of Lead Contamination

Figure 4.1.5-7 shows the distribution of lead in soil and groundwater in the Slag Pile Area along the A to A' transect. Like arsenic, soil lead concentrations above the IRSL consistently decrease with depth. Though concentrations may vary (e.g., boring SB-309 where concentrations increase and then decrease with depth), the lead concentrations at the deepest soil sample interval(s) of each boring shown on Figure 4.1.5-7 are below the RRSL. The distribution of groundwater lead detections above the MCL was limited to the down-gradient well (MW-2), the screened interval of which is uncertain and which may be screened across multiple lithologic units.

Figure 4.1.5-8 shows the soil and groundwater lead data from the west to east cross section through the Plant Area (transect B to B'). Soil lead concentrations greater than the IRSL along the cross section north of the Plant Area (transect B to B' in Figure 4.1.5-8) were limited to two samples: SB-318, 0 to 1 ft bgs (collected in surface fill), and C-11, 0 ft bgs (collected in surface fill and slag). Sampling below these locations demonstrates that lead concentrations decrease to below the IRSL with depth. The highest reported groundwater lead concentration in the Plant Area was from groundwater collected in surface fill (G-05, 2,180 µg/L) (Figure 4.1.5-8). Concentrations of lead in groundwater decrease from west to east toward the LVR. Groundwater concentrations reported from MW P-18 (the farthest well east), which is partially screened in slag, had no detectable lead. Soil lead concentrations in the immediate area of well P-18 were as high as 500 mg/kg at SB-308 (26.6 to 27 ft bgs) but decrease to 53 mg/kg at SB-308 (36.5 to 37 ft bgs), at depths approaching the screen interval of P-18.

Vertical Extent of Manganese Contamination

Figure 4.1.5-9 shows the distribution of manganese in soil and groundwater in the Slag Pile Area (transect A to A'). Manganese concentrations in soil in the Slag Pile Area varied from 23.6 to 123,000 mg/kg (Tables 4.1.2-15 and 4.1.2-16). The soil samples with manganese concentrations above the RRSL were most frequently from south of the Slag Pile (Figure 4.1.5-9). The highest manganese concentration measured in slag (40,600 mg/kg) was from location P-15A at a depth of 20 ft bgs. This location is the soil sampling location farthest south of the Slag Pile and the reported concentration is below the IRSL. The only soil manganese concentration above the IRSL in the Slag Pile Area was from a fill sample (MW-303H, 0 to 1 ft bgs, 123,000 mg/kg) overlying the main Slag Pile. Manganese concentrations in soil samples adjacent to MW-303H were at least three orders of magnitude lower, suggesting that higher concentrations of manganese are limited to the immediate area of sample MW-303H at 0 to 1 ft bgs. Manganese concentrations in groundwater samples also have a high level of variability with

concentrations ranging from 106 to 16,900 µg/L. Groundwater manganese levels were highest in the unconsolidated native media directly underlying the Slag Pile (MW-322H, MW-305H, P-1, and MW-321H) with lower concentrations reported south of the Slag Pile (P-17, P-18, MW-2, and P-15).

Figure 4.1.5-10 shows the soil and groundwater manganese data from the west to east cross section through the Plant Area (transect B to B'). A similar sporadic distribution of manganese in soil and groundwater is apparent in the cross section for the Plant Area (Figure 4.1.5-10). Only one measured manganese concentration was above the IRSL in one surface fill soil sample (SSI-X102, 0 ft bgs) collected in the Plant Area; the sample had a manganese concentration of 118,000 mg/kg. Groundwater manganese concentrations decrease from west to east (transect B to B') along the side slope to the LVR from P-7 to P-18 (Figure 4.1.5-10). Concentrations of manganese in groundwater samples decrease from 19,600 µg/L (P-7) to less than the Tap Water RSL along the LVR in MW P-18 (106 µg/L). These results suggest that manganese is not mobilized from the Slag Pile and into the LVR by means of groundwater migration.

Vertical Extent of Zinc Contamination

Figure 4.1.5-11 shows the distribution of zinc in soil and groundwater in the Slag Pile Area (transect A to A'). The vertical distribution of zinc at OU1 was evaluated because the Site is a former zinc smelting facility; whereas the vertical distributions of arsenic, lead, and manganese were evaluated because these were the most prevalent metals at OU1. Zinc concentrations were below the IRSL in all Slag Pile soil samples (Tables 4.1.2-15 and 4.1.2-16). Zinc concentrations were above the RRS� in samples collected from surface fill (P-21, 2.5 ft bgs; ISA-X105, 0 to 0.8 ft bgs; and MW-304S, 0 to 1 ft bgs), the slag surface (MW-301H, 0 to 1 ft bgs), and at or around the contact between the slag and unconsolidated native media (SB-309, 48 to 29 ft bgs; SB-308, 26.7 to 27 ft bgs; MW-304S, 59 to 60 ft bgs; and MW-301H, 0 to 1 ft bgs and 40 to 41 ft bgs). Groundwater concentrations ranged from less than 20 µg/L (MW-303H) to 831,000 µg/L (P-1) between the slag and unconsolidated native media (Table 4.1.3-8 and Figure 4.1.5-11). Zinc concentrations in wells screened within the unconsolidated native media were highest under the Slag Pile (MW-322H and P-1), though this was not always the case (MW-305H, MW-303H, ISW-002, MW-321H, and ISW-001). Groundwater zinc concentrations for wells screened within the unconsolidated native media decrease an order of magnitude from MW-322H (34,500 µg/L) south to MWs P-18 (3,120 µg/L) and P-17 (2,670 µg/L). This decrease in groundwater zinc concentrations continues south to MW P-15 (517 µg/L).

Figure 4.1.5-12 shows the soil and groundwater zinc data from the west to east cross section through the Plant Area (transect B to B'). Soil zinc concentrations in the Plant Area show a trend of increasing concentrations from west to east. Zinc concentrations above the RRS� occur in two samples along the B to B' transect (see SB-315, 0 to 1 ft bgs; and SB-308, 26.5 to 27 ft bgs in Figure 4.1.5-12). The higher zinc concentrations in sample SB-315 (0 to 1 ft bgs) are localized as shown by concentrations less than the RRS� measured in adjacent soil samples (C-9, 0 ft bgs; and SB-318, 0 to 1 ft bgs) and underlying soil samples (SB-315, two to four ft bgs; and SB-315, two to four ft bgs). Sample SB-308 (26.5 to 27 ft bgs) is located at the contact between the slag and underlying unconsolidated native media. Zinc soil concentrations are above the RRS� in SB-308 (36.5 to 37 ft bgs). Groundwater samples from location P-18, approximately 175 ft away which is screened in the slag material, indicates that slag zinc has a relatively low mobility. The zinc concentration in the groundwater sample from P-18 is 3,120 µg/L, which is below the Tap Water RSL for zinc (Figure 4.1.5-12). Groundwater zinc concentrations above the Tap Water RSL were limited to wells screened in probable slag (MW-1), slag (G-106), and rubble (P-7). These wells are in the vicinity and/or down slope of the relatively high zinc concentration measured in SB-315 (26,500 mg/kg 0 to 1 ft bgs). The pattern of higher groundwater zinc concentrations in upslope wells screened within the slag (G-106 and P-7) and lower groundwater zinc concentrations in down slope wells (P-19 and P-18) suggest that zinc concentrations attenuate with increased distance from G-106 and P-7 (Figure 4.1.5-12). P-19 is an exception to this pattern since the groundwater zinc concentration is 6,460 µg/L, which is higher than 3,120 µg/L measured at P-18 (Figure 4.1.5-12).

4.1.5.2 Vertical Extent of VOC Contamination in Soil and Groundwater

VOC concentrations in all soil samples from OU1 were below their respective SVs, so there is no impact to soil from VOCs.

The concentrations of two VOCs (1,2-dichloroethane and VC) were above their respective SVs in the same Plant Area groundwater sample collected from G-103 (Table 4.1.3-4 and Figure 4.1.3-3b). The groundwater sample at G-103 was collected from 12 to 22 ft bgs. These results show that the vertical extent of VOC impacts in the Plant Area is 12 to 22 ft bgs. VOC concentrations were below their respective SVs in Slag Pile Area groundwater samples. Because groundwater in the Plant Area discharges to the Slag Pile Area, the lack of exceedances of SVs for VOCs in the Slag Pile Area means that the vertical extent of VOC groundwater impact has been established.

4.1.5.3 Vertical Extent of SVOC Contamination in Soil and Groundwater

Concentrations of six SVOCs were above their respective SVs in three Plant Area shallow soil samples (Table 4.1.2-9 and Figure 4.1.2-3). The SVOCs included the following:

- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Dibenzo(a,h)anthracene
- Indeno(1,2,3-cd)pyrene

The samples were collected from SB-311, SB-315, and SSI-X102 (Table 4.1.2-9 and Figure 4.1.2-3). The concentrations of all SVOCs were below their respective SVs in all Plant Area deep soil samples. Therefore, the vertical extent of SVOC impacts in Plant Area soils is within two ft of the surface of SB-311, SB-315, and SSI-X102.

Concentrations of two SVOCs (benzo(a)pyrene and hexachlorobenzene) were above their respective SVs in two Slag Pile Area shallow soil samples (Table 4.1.2-21 and Figure 4.1.2-7). The samples were collected from ISA-X106 and MW-306S (Table 4.1.2-21 and Figure 4.1.2-7). The concentrations of six SVOCs were above their respective SVs in four Slag Pile Area deep soil samples. Identical to the SVOCs in the Plant Area, the SVOCs with concentrations above their respective SVs in the Slag Pile Area included the following (Table 4.1.2-22 and Figure 4.1.2-8):

- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Dibenzo(a,h)anthracene
- Indeno(1,2,3-cd)pyrene

The samples were collected from MW-303H, SB-307, SB-308, and SB-316 (Table 4.1.2-22 and Figure 4.1.2-8); the sampling depths ranged from two to 90 ft bgs. Therefore, the vertical extent of SVOC impacts in Slag Pile Area soils is 0 to 90 ft bgs.

One SVOC concentration (bis(2-ethylhexyl)phthalate) was above its SV in one Plant Area groundwater sample collected in 1991 (G-106 in Table 4.1.3-5 and Figure 4.1.3-4a). SVOC concentrations were below their respective SVs in Slag Pile Area groundwater samples. The groundwater sample at G-106 was collected from 15.3 to 30.3 ft bgs. These results show that the vertical extent of SVOC impacts in the Plant Area is 15.3 to 30.3 ft bgs. SVOC concentrations were below their respective SVs in Slag Pile Area groundwater samples (Table 4.1.3-9).

4.1.5.4 Vertical Extent of PCB Contamination in Soil and Groundwater

Concentrations of two PCBs (Aroclor 1254 and Aroclor 1260) were above their respective SVs in the same shallow soil sample collected from SSI-X102 in the Plant Area (Table 4.1.2-11 and Figure 4.1.2-4). The concentrations of PCBs were below their respective SVs in all deep soil samples from OU1. Therefore, the vertical extent of PCB impacts in OU1 soils is within two ft of the surface.

PCB concentrations in all groundwater samples from OU1 were below their respective SVs, so there is no known impact to groundwater from PCBs.

4.1.5.5 Vertical Extent of Pesticides Contamination in Soil and Groundwater

Pesticide concentrations in all soil and groundwater samples from OU1 were below their respective SVs, so there is no known impact to soil or groundwater from pesticides.

4.1.6 Horizontal Extent of Contamination in OU1

This section describes the horizontal extent of contamination in OU1. [Section 4.1.6.1](#) describes the horizontal extent of contamination in soils. 4.1.6.2 describes the horizontal extent of contamination in groundwater. [Section 4.1.6.3](#) describes the horizontal extent of contamination in sediment and surface waters.

4.1.6.1 Horizontal Extent of Contamination in Soils

This section describes the horizontal extent of impacts in Plant Area and Slag Pile Area soils.

Horizontal Extent of Contamination in Plant Area Soils

This section describes the horizontal extent of impacts in Plant Area soils. The contaminants discussed below include metals, cyanide, VOCs, SVOCs, PCBs, and pesticides.

Metals

Measured concentrations of metals were above their respective SVs in shallow and deep soils from the Plant Areas. The most prevalent metals found above their respective SVs in Plant Area soils were arsenic and manganese. Other metals that were measured above their respective SVs in Plant Area soils were cobalt, iron, lead, mercury, and zinc.

Arsenic and manganese were measured at concentrations above their respective SVs in Plant Area soils in various locations and were not concentrated in a particular section of the Plant Area (Figures 4.1.2-1 and 4.1.2-2).

Lead concentrations were above its SV in soil (southeast of the Plant Area in borings C-11 and SB-318, Figure 4.1.2-1) and Plant Area soil (southeast of the Plant Area in boring C-11, Figure 4.1.2-2).

Cobalt concentrations were above its SV in one Plant Area soil sample (SB-314 on Figure 4.1.2-2). Sample SB-314 was collected in the middle of the Plant Area at a depth of 2 to 4 ft bgs, and is delineated to concentrations less than the SV in adjacent borings to the north (SB-312), west (SB-311 and G-03), south (SB-313, SB-317 and SB-319), and east (C-5, SB-31, C-9, C-10, SB-318, and C-11).

Iron was measured at concentrations above its SV in soils in the Plant Area next to the Slag Pile (locations C-11 and SB-318 on Figure 4.1.2-1).

Mercury concentrations above the SV in one Plant Area soil sample collected from the southeastern sampling boundary (SB-318 on Figure 4.1.2-1). The absence of mercury concentrations above the SV in other Plant Area soil samples, suggests that the area of elevated mercury is limited horizontally.

Zinc concentrations were above its RRS in 1 of 15 soil samples. This sample was located on the eastern half of the Plant Area (SB-315 on Figure 4.1.2-1).

Cyanide

Measured cyanide concentrations in Plant Area soils were below its SV, so there is no known impact to OU1 soils from cyanide.

VOCs

Measured VOC concentrations in Plant Area were all below their respective SVs, so there is no known impact to OU1 soils from VOCs.

SVOCs

SVOC concentrations were above their respective SVs in soils from the Plant Area. The most prevalent SVOC found above its SV in Plant Area soils was benzo(a)pyrene. Other SVOCs measured above their respective SVs in Plant Area soils were benzo(a)anthracene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

Three Plant Area soil samples each had SVOC concentrations above their respective SVs (SB-311, SB-315, and SSI-X102 on Figure 4.1.2-3). These exceedances of SVs occurred at isolated locations and were not present in adjacent samples. Accordingly, these results show that the horizontal extent of SVOC impacts in Plant Area soils is likely limited to SB-311, SB-315, and SSI-X102 (Figure 4.1.2-3)

PCBs

PCB concentrations were above their respective SVs in one Plant Area shallow soil sample. The soil sample was collected from the center of the Plant Area and contained Aroclor 1254 and Aroclor 1260 (SSI-X102 on Figure 4.1.2-4). No other PCBs were found above their SVs in shallow or deep Plant Area soils or in the Slag Pile Area. These results show that the horizontal extent of PCB impacts in OU1 soils is likely limited to SSI-X102 in the Plant Area.

Pesticides

All pesticides concentrations were below their respective SVs in shallow and deep soil samples from the Plant Area, so there is no known impact to Plant Area soils from pesticides.

Collocation

COIs measured above SVs in Plant Area soils include metals, SVOCs, and PCBs (Figures 4.1.2-1 to 4.1.2-4). The description of the collocation of various COIs is for the purpose of investigating whether there are areas that appear to be impacted by different COI groups and may require differing remedial technologies. The collocation of COIs may also be suggestive of a source of contamination.

Metals impact is present across the Plant Area and does not indicate any pattern or source of the impacts. PCBs exceeded SVs at a single Plant Area location (SSI-X201), and SVOCs exceeded SVs at three widely dispersed Plant Area locations, ranging from the far northwest corner across the center of the Plant Area to the eastern edge (Figure 4.1.2-3). There does not appear to be collocation of the contaminant groups within the soil samples in the Plant Area. The broad extent of the metals includes the locations impacted by the other COIs, but the PCB and SVOC COIs show no evidence of collocation or a common source.

Horizontal Extent of Contamination in Slag Pile Soils

This section describes the horizontal extent of impacts in Slag Pile Area soils. The contaminants discussed below include metals, cyanide, VOCs, SVOCs, PCBs, and pesticides.

Metals

Measured concentrations of metals were above their respective SV in shallow and deep Slag Pile Area soils. Arsenic and manganese were measured at concentrations above their respective SVs in shallow and deep Slag Pile Area soils in various locations and were not concentrated in a particular area of the Slag Pile (Figures 4.1.2-5 and 4.1.2-6). Other metals with SV exceedances not concentrated in a particular area of the Slag Pile were lead in surface soils, cobalt in shallow and deep soils, iron in deep soils, and zinc in deep soils. Cadmium concentrations were above its SV in four shallow and four deep Slag Pile Area samples limited to the northern portion of the Slag Pile (Figure 4.1.2-6). Antimony concentrations above the SV were limited to two deep soil samples just east of the holding pond in the Slag Pile Area (SB-309 and SB-308 on Figure 4.1.2-6). The copper concentration in one shallow soil sample from the northern end of the Slag Pile was above its SV (ISA-X106 on Figure 4.1.2-5). The concentration of copper in adjacent borings to the north (MW-301H), east (SB302 and MW-304S), and south (MW-303H) provide horizontal delineation for copper in these directions. Shallow Slag Pile mercury results indicate that mercury concentrations above the SV are limited to the two northernmost shallow Slag Pile samples (SB-302 and MW-301H on Figure 4.1.2-5). Mercury concentrations above the SV in deep Slag Pile soil samples were limited to one sample (MW-305H) at a depth of 89 to 90 ft bgs (Figure 4.1.2-6). Zinc concentrations above the SV in shallow Slag Pile soil were limited to four locations in the northern portion of the Slag Pile (Figure 4.1.2-5). Overall, metals concentrations in excess of SVs are not concentrated in any particular area of the Slag Pile.

Cyanide

Measured cyanide concentrations in Slag Pile Area shallow and deep soils were below its SV, so there is no known impact to Slag Pile Area soils from cyanide.

VOCs

Measured VOC concentrations in shallow and deep soils were all below their respective SVs, so there is no known impact to Slag Pile Area soils from VOCs.

SVOCs

Measured concentrations of SVOCs were above their respective SVs in shallow and deep Slag Pile Area soils. The most prevalent SVOC found above its SV in Slag Pile Area soils was benzo(a)pyrene. Other SVOCs that were measured above their respective SVs in soils were benzo(a)anthracene,

benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, hexachlorobenzene, and indeno(1,2,3-cd)pyrene.

Two shallow Slag Pile soil samples (ISA-X106 and MW-306S) each had one SVOC detection above its SV (Figure 4.1.2-7). These results show that SVOC impacts in shallow Slag Pile soils is limited to MW-306S and ISA-X106. Four deep Slag Pile soil samples had SVOC concentrations above their respective SV (MW-303H, SB-307, SB-308, and SB-316 on Figure 4.1.2-8). These exceedances of SVs occurred at isolated locations and were not present in adjacent samples. Accordingly, these results show that the horizontal extent of SVOC impact in deep Slag Pile Area soils is limited to the four borings cited above (Figure 4.1.2-8).

PCBs

All PCB concentrations were below their respective SVs in shallow and deep Slag Pile Area soils, so there is no known impact to Slag Pile Area soils from PCBs.

Pesticides

All pesticides concentrations were below their respective SV in shallow and deep Slag Pile Area soils, so there is no known impact to Slag Pile Area soils from pesticides.

Collocation

COIs measured above SVs in Slag Pile Area soils include metals and SVOCs (Figures 4.1.2-5 to 4.1.2-8). The description of the collocation of various COIs is for the purpose of investigating whether there are areas that appear to be impacted by different COI groups and may require differing remedial technologies. The collocation of COIs may also be suggestive of a source of contamination.

Metals impact is present across the Slag Pile Area and does not indicate any pattern or source of the impacts other than the general disposal of slag. SVOCs in excess of SVs were detected in six locations from the Slag Pile Area. The exceedances appear to be discrete but are distributed along the length of the Slag Pile from near the north end to near the south end. There does not appear to be any distinguishable collocation of the contaminant groups within the soil samples in the Slag Pile Area. The broad extent of the metals includes the locations impacted by the other COIs, but the SVOC COIs show no evidence of collocation or a common source.

4.1.6.2 Horizontal Extent of Contamination in Groundwater

This section describes the horizontal extent of groundwater impacts in the Plant and Slag Pile Areas.

Horizontal Extent of Contamination in Plant Area Groundwater

This section describes the horizontal extent of Plant Area groundwater impacts. The contaminants discussed below include metals, cyanide, VOCs, SVOCs, PCBs, and pesticides.

Metals

Twenty-four Plant Area groundwater samples from six wells had detections of total or dissolved metals concentrations above their respective SVs (Table 4.1.3-3). The most prevalent metals found above their respective SVs in Plant Area groundwater were arsenic, cadmium, cobalt, and manganese (Table 4.1.3-2). Other metals that were measured above their respective SVs in Plant Area groundwater were aluminum, barium, beryllium, chromium, iron, lead, mercury, vanadium, and zinc (Table 4.1.3-2). The horizontal extent of impacts for each metal is described in alphabetical order below.

Aluminum concentrations were above its SV in three, historical groundwater Plant Area samples from three wells on the northeastern portion of the Plant Area (G-101, G-103, and G-106 on Figure 4.1.3-2a). These results suggest that the groundwater aluminum impact is limited to wells G-101, G-103, and G-106 in the Plant Area.

Arsenic concentrations were above its SV in 18 groundwater Plant Area samples from 6 wells on the eastern half of the Plant Area (Figures 4.1.3-1a, 4.1.3-1b, 4.1.3-2a, and 4.1.3-2b). Figures 4.1.3-1a, 4.1.3-1b, 4.1.3-2a, and 4.1.3-2b show that the groundwater arsenic impact is limited to the eastern portion of the Plant Area. Wells installed on the western portion of the Site did not produce sufficient water to sample.

Barium concentrations were above its SV in two groundwater Plant Area samples from one well (G-103 on Figure 4.1.3-2a). These results suggest that the groundwater barium impact is limited to G-103 in the Plant Area.

Beryllium concentrations were above its SV in two groundwater Plant Area samples from two wells on the northeastern edge of the Plant Area (G-103 and G-106 on Figure 4.1.3-2a). These results suggest that the groundwater beryllium impact is limited to wells G-103 and G-106 in the Plant Area.

Cadmium concentrations were above its SV in 13 groundwater Plant Area samples from 5 wells on the eastern half of the Plant Area (Figures 4.1.3-1a, 4.1.3-1b, 4.1.3-2a, and 4.1.3-2b). Figures 4.1.3-1a, 4.1.3-1b, 4.1.3-2a, and 4.1.3-2b show that the groundwater cadmium impact is limited to the eastern portion of the Plant Area. Wells installed on the western portion of the Site did not produce sufficient water to sample.

Chromium concentrations were above its SV in four groundwater Plant Area samples from three wells on the eastern edge of the Plant Area (G-103, G-106, and G-02 on Figure 4.1.3-2a). These results suggest that the groundwater chromium impact is limited to wells G-103, G-106, and G-02 in the Plant Area.

Cobalt concentrations were above its SV in 10 groundwater Plant Area samples from 5 wells on the eastern half of the Plant Area (Figures 4.1.3-1a, 4.1.3-2a, and 4.1.3-2b). Figures 4.1.3-1a, 4.1.3-2a, and 4.1.3-2b show that the groundwater cobalt impact is limited to the eastern portion of the Plant Area. Wells installed on the western portion of the Site did not produce sufficient water to sample.

Iron concentrations were above its SV in three groundwater Plant Area samples from three wells on the eastern edge of the Plant Area (G-101, G-103, and G-106 on Figure 4.1.3-2a). These results suggest that the groundwater iron impacts is limited to wells G-101, G-103, and G-106 in the Plant Area.

Lead concentrations were above its SV in seven groundwater Plant Area samples from four wells on the eastern half of the Plant Area (G-05, G-101, G-103, and G-106 on Figures 4.1.3-1a and 4.1.3-2a). Figures 4.1.3-1a and 4.1.3-2a show that the groundwater lead impact is limited to the eastern portion of the Plant Area, and that the lead impacts were observed in historical groundwater samples. Wells installed on the western portion of the Site did not produce sufficient water to sample.

Manganese concentrations were above its SV in 16 groundwater Plant Area samples from 6 wells on the eastern half of the Plant Area (Figures 4.1.3-1a, 4.1.3-1a, 4.1.3-2a, and 4.1.3-2b). Figures 4.1.3-1a, 4.1.3-1b, 4.1.3-2a, and 4.1.3-2b show that the groundwater manganese impact is limited to the eastern portion of the Plant Area. Wells installed on the western portion of the Site did not produce sufficient water to sample.

Mercury concentrations were above its SV in two groundwater Plant Area samples from two wells (G-05 and G-101 on Figure 4.1.3-2a). These results suggest that the groundwater mercury impact is limited to wells G-05 and G-101 in the Plant Area.

One groundwater sample from the Plant Area had a vanadium concentration above its SV (G-103 on Figure 4.1.3-2a). These results suggest that the groundwater vanadium impact is limited to G-103 in the Plant Area.

Zinc concentrations were above its SV in six groundwater samples from two wells located on the eastern side of the Plant Area (G-106 and MW-A on Figures 4.1.3-1b, 4.1.3-2a, and 4.1.3-2b). These results suggest that the groundwater zinc impact is limited to wells G-106 and MW-A in the Plant Area.

Cyanide

Cyanide concentrations were below their respective SV in all Plant Area groundwater samples, so there is no known impact to Plant Area groundwater from cyanide.

VOCs

VOC concentrations were above their respective SVs in one groundwater sample located near the eastern margin of Plant Area (G-101 on Figure 4.1.3-3b). Two VOCs had concentrations in the sample from G-101 above their respective SVs, 1,2-dichloroethane and VC. These results show that the horizontal extent of VOC impacts in groundwater on OU1 is limited to the area near G-101. The wells in the northern and western portions of the Plant Area did not have sufficient water to sample. While VOCs were present on OU2 in this vicinity, the relatively flat gradient between OU2 and the Plant Area, and the limited groundwater in wells in this area suggest VOCs have not impacted this portion of the Plant Area of OU1.

SVOCs

One groundwater sample had a bis(2-ethylhexyl)phthalate concentration above its SV from G-106. G-106 was located along the border of the Plant and Slag Pile Areas (Figure 4.1.3-4a). These results suggest that the horizontal extent of SVOC impacts in groundwater is limited to the area near G-106.

PCBs

PCB concentrations were below their respective SV in all Plant Area groundwater samples, so there is no known impact to Plant Area groundwater from PCBs.

Pesticides

Pesticide concentrations were below their respective SV in all Plant Area groundwater samples, so there is no known impact to Plant Area groundwater from pesticides.

Horizontal Extent of Contamination in Slag Pile Area Groundwater

This section describes the horizontal extent of impacts in Slag Pile Area groundwater. The contaminants discussed below include metals, cyanide, VOCs, SVOCs, PCBs, and pesticides.

Metals

Thirty-nine Slag Pile Area groundwater samples from 16 wells had detections of total or dissolved metals concentrations above their respective SV. The most prevalent metals found above their respective SVs in Slag Pile Area groundwater were arsenic, cadmium, cobalt, and manganese. Other metals measured above their respective SVs in Slag Pile Area groundwater were copper, iron, lead, mercury, nickel, and zinc. The horizontal extent of impact for each metal is described below.

Arsenic concentrations were above its SV in 22 Slag Pile Area groundwater samples from 10 wells (Figures 4.1.3-5a, 4.1.3-5b, 4.1.3-6a, and 4.1.3-6b). Figures 4.1.3-5a, 4.1.3-5b, 4.1.3-6a, and 4.1.3-6b show that the horizontal extent of groundwater arsenic impact generally covers the Slag Pile, as evident in the following 10 wells:

- MW-1
- MW-2
- ISW-001
- ISW-002
- MW-321H
- MW-322H
- P-7
- P-9
- P-17
- P-18

Cadmium concentrations were above its SV in 15 groundwater samples from 8 wells in the Slag Pile Area (Figures 4.1.3-5a, 4.1.3-6a, and 4.1.3-6b). Figures 4.1.3-5a, 4.1.3-6a, and 4.1.3-6b show that the horizontal extent of groundwater cadmium impact generally covers the Slag Pile, as evident in the following eight wells:

- MW-1
- MW-2
- ISW-001
- ISW-002
- P-1
- P-9
- P-18
- P-19

Cobalt concentrations were above its SV in 14 groundwater samples from 7 wells in the Slag Pile Area (Figures 4.1.3-5a, 4.1.3-5b, 4.1.3-6a, and 4.1.3-6b). Figures 4.1.3-5a, 4.1.3-5b, 4.1.3-6a, and 4.1.3-6b

show that the horizontal extent of groundwater cobalt impacts generally extend across the entire Slag Pile, as evident in the following seven wells:

- MW-2
- ISW-001
- ISW-002
- MW-322H
- P-7
- P-9
- P-17

One Slag Pile groundwater sample had a copper concentration above its SV from MW-2; this well is located in the southeast area of the Slag Pile (Figure 4.1.3-6a). These results suggest that the groundwater copper impact is limited to MW-2 in the Slag Pile Area.

Iron concentrations were above its SV in five groundwater samples from two wells in the Slag Pile Area (ISW-002 and MW-2 on Figures 4.1.3-5b, 4.1.3-6a, and 4.1.3-6b). These results suggest that the groundwater iron impact is limited to ISW-002 and MW-2 in the Slag Pile Area.

Lead concentrations were above its SV in ten groundwater samples from five wells in the Slag Pile Area (P-6, ISW-001, ISW-002, MW-1 and MW-2 on Figures 4.1.3-5a, 4.1.3-6a, and 4.1.3-6b). These results suggest that the groundwater lead impact is limited to these five wells which are fairly widely distributed across the Slag Pile Area.

Manganese concentrations were above its SV in 34 Slag Pile Area groundwater samples from all 16 wells sampled (Figures 4.1.3-5a, 4.1.3-5b, 4.1.3-6a, and 4.1.3-6b). Figures 4.1.3-5a, 4.1.3-5b, 4.1.3-6a, and 4.1.3-6b show that the horizontal extent of groundwater manganese impact is widespread in the Slag Pile Area.

One Slag Pile groundwater sample had a mercury concentration above its SV from MW-2; this well is located in the southeast area of the Slag Pile (Figure 4.1.3-6a). These results suggest that the groundwater mercury impact is limited to MW-2 in the Slag Pile Area.

One Slag Pile groundwater sample had a nickel concentration above its SV from P-1; this well is located in northern area of the Slag Pile (Figure 4.1.3-6a). These results suggest that the groundwater nickel impact is limited to P-1 in the Slag Pile Area.

Zinc concentrations were above its SV in eight groundwater samples from six wells in the Slag Pile Area (Figures 4.1.3-5a, 4.1.3-5b, 4.1.3-6a, and 4.1.3-6b). Figures 4.1.3-5a, 4.1.3-5b, 4.1.3-6a, and 4.1.3-6b

show that the horizontal extent of groundwater cobalt impact is limited to the eastern portion of the Slag Pile, as evident in the following six wells:

- MW-2
- ISW-002
- MW-322H
- P-1
- P-7
- P-18

Cyanide

Cyanide concentrations were below its SV in all Slag Pile Area groundwater samples, so there is no known impact to Slag Pile Area groundwater from cyanide.

VOCs

VOC concentrations were below their respective SVs in all Slag Pile Area groundwater samples, so there is no known impact to Slag Pile Area groundwater from VOCs.

SVOCs

SVOC concentrations were below their respective SVs in all Slag Pile Area groundwater samples, so there is no known impact to Slag Pile Area groundwater from SVOCs.

PCBs

PCB concentrations were below their respective SVs in all Slag Pile Area groundwater samples, so there is no known impact to Slag Pile Area groundwater from PCBs.

Pesticides

Pesticide concentrations were below their respective SVs in all Slag Pile Area groundwater samples, so there is no known impact to Slag Pile Area groundwater from pesticides.

Collocation Across OU1 (Plant Area and Slag Pile Area) Groundwater

COIs measured above SVs in OU1 groundwater consist of metals, VOCs and SVOCs (Figures 4.1.3-1 through 4.1.3-6b). The description of the collocation of various COIs is for the purpose of investigating whether there are areas that appear to be impacted by different COI groups and may require differing remedial technologies. Additionally, co-located impacts in groundwater or collocation with soil impacts may indicate a potential source area.

Metals impact in groundwater is generally present across all of OU1 and does not indicate any pattern or source of the impacts other than the general disposal of sinter and slag materials. This is the case for both dissolved concentrations as well as totals.

The VOC groundwater exceedances of SVs are present in one well (G-103), which is located along the far eastern edge of the Plant Area. One SVOC COI was measured above the SV in groundwater, bis(2-ethylhexyl)phthalate. That COI was measured in well G-106, also located along the eastern margin of the Plant Area. While these two wells are in the same general area of the plant, they are approximately 175 ft apart. The fact that they do not share any COI exceedances or even detections suggests these impacts are not related to a common plume. Additionally, the VOCs and SVOC detected in groundwater were not measured in any vicinity soil samples. There does not appear to be any distinguishable collocation of the contaminant groups within the groundwater samples in OU1.

4.1.6.3 Horizontal Extent of Contamination in Sediment and Surface Water

The following sections describe the horizontal extent of metals impacts in OU1 sediments and surface water, respectively. Since metals can be transported between sediments and surface waters ([Section 5.1.2](#)), metals impacts in sediments and surface water are discussed together in the following sections in alphabetical order.

Horizontal Extent of Contamination in Slag Pile Sediments

This section describes the horizontal extent of impacts in Slag Pile Area sediments. The contaminants discussed below include metals, cyanide, VOCs, SVOCs, PCBs, and pesticides.

Metals

Measured concentrations of metals were above their respective SVs in sediment from the Slag Pile Area. The concentrations of the following metals were above their respective SVs in all or several of the Slag Pile Area sediment samples:

- Arsenic
- Cadmium
- Chromium
- Copper
- Lead
- Mercury
- Nickel
- Zinc

Silver exceeded its SV in one sample (UL-215) (Figure 4.1.4-1). These samples were collected from the holding pond, and west of the Slag Pile (UL-215) in the Slag Pile Area (Figure 4.1.4-1). These results suggest that the horizontal extent of impacts of metals in Slag Pile Area sediments are within the holding pond and its immediate vicinity (Figure 4.1.4-1).

Cyanide

Cyanide concentrations were below its SV in all Slag Pile Area sediment samples, so there is no known impact to Slag Pile Area sediments from cyanide.

VOC

Two Slag Pile sediment samples out of three locations sampled had acetone concentrations above its SV. Both samples were collected from the holding pond (SSI-X206 and SSI-X205, Figure 4.1.4-2). These samples are from 1991 and may represent a laboratory artifact.

SVOC

The concentrations of 15 SVOCs were above their respective SVs in Slag Pile Area sediments. The SVOCs included the following (Table 4.1.4-3):

- Acenaphthene
- Acenaphthylene
- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Bis(2-ethylhexyl)phthalate
- Carbazole
- Chrysene
- Dibenzo(a,h)anthracene
- Fluoranthene
- Indeno(1,2,3-cd)pyrene
- Phenanthrene
- Pyrene

The concentrations of all 15 SVOCs were above their respective SVs in the sample from UL-215 (Figure 4.1.4-3). The concentrations of nine SVOCs were above their respective SVs in the sample from SSI-X206, and one SVOC was above its SV in the sample from SSI-X205. Both SSI-X206 and SSI-X205 were located in the holding pond. These results show that the horizontal extent of SVOC impacts to Slag Pile Area sediments is limited to the holding pond and its immediate vicinity.

PCBs

The concentrations of two PCBs were above their respective SVs in Slag Pile sediments; the PCBs were Aroclors 1254 and 1260 (Table 4.1.4-10). The concentration of Aroclor 1254 was above its SV in the sediment sample collected from SSI-X206 (in the holding pond on Figure 4.1.4-4). The concentration of Aroclor 1260 was above its SV in the sediment sample collected from UL-215 (Figure 4.1.4-4). Therefore, the horizontal extent of PCB impacts in Slag Pile Area sediments is limited to the holding pond and its vicinity.

Pesticides

Pesticides concentrations in all Slag Pile sediment samples were below their respective SV, so there is no known impact to Slag Pile Area sediments from pesticides.

Collocation

COIs measured above SVs in Slag Pile Area sediments consist of metals, VOCs, SVOCs, and PCBs (Figures 4.1.4-1 through 4.1.4-4). However, all of the sediment samples from the Slag Pile Area are limited to a small area consisting of the holding pond and the seep area located to the west of the Slag Pile. The description of the collocation of various COIs is for the purpose of investigating whether there are areas that appear to be impacted by different COI groups and may require differing remedial technologies. Co-located sediment exceedances may indicate source areas or locations where sediment is accumulating from different sources. Based on the limited distribution of these samples, it is concluded the sediment in the holding pond is impacted with the investigated COIs. The seep area is a separate location with separate source areas. There does not appear to be any relationship between these two locations regarding source of the impacts.

Horizontal Extent of Contamination in LVR Sediments and Surface Water

This section describes the horizontal extent of impacts in LVR sediment and surface water. The contaminants discussed below include metals, cyanide, VOCs, SVOCs, PCBs, and pesticides.

Metals

Measured concentrations of metals were above their respective SVs in sediment and surface water from the LVR. The most prevalent metals found above their respective SVs in LVR sediment were cadmium,

copper, and zinc. Other metals measured above their respective SVs in LVR sediments included the following:

- Arsenic
- Cobalt
- Lead
- Mercury
- Nickel
- Silver

The most prevalent metals in surface water samples from the LVR at concentrations above their respective SVs were aluminum, nickel, and zinc. Other metals present in LVR surface water at concentrations above their respective SVs included the following:

- Cadmium
- Chromium
- Copper
- Iron
- Lead
- Selenium
- Silver

The horizontal extent of these metals is described in alphabetical order below.

Aluminum concentrations were below its SV in all LVR sediment samples. Surface water aluminum concentrations were above its SV in 28 samples collected from 17 locations in the LVR, including those upstream of the Site (Table 4.1.4-10). The LVR surface water samples with aluminum concentrations above its SV were collected along the entire stretch of the LVR sampled (Figure 4.1.4-7). These results suggest that aluminum impact is widespread in LVR surface waters and that the impact may not be entirely attributable to the Site.

Sediment arsenic concentrations were above its SV in 12 samples from the LVR (Table 4.1.4-9). The LVR sediment samples with arsenic concentrations above its SV were collected along the LVR next to and south of the Slag Pile and downstream of the ASO and CSO discharges (Figure 4.1.4-5). These results suggest that site features may be a source of arsenic impact to LVR sediments. Arsenic concentrations were below its SV in all surface water samples from LVR.

Sediment cadmium concentrations were above its SV in 48 samples from the LVR (Table 4.1.4-9) and those samples were collected along the entire stretch of LVR sampled, including locations upstream of the Site (Figure 4.1.4-5). These results show that cadmium impact is widespread in LVR sediments and that the impact may not be entirely attributable to the Site. Surface water cadmium concentrations were above its SV in 24 samples collected from 4 locations in the LVR (Table 4.1.4-10). Cadmium concentrations

were highest at ASO-411, and all other surface water samples with cadmium concentrations above the SV were collected downstream of ASO-411 (Figure 4.1.4-6 and 4.1.4-7). These results suggest that the source of cadmium impact in LVR surface water is the ASO. These results also suggest that the ASO may be the source of cadmium impact in LVR sediments downstream of the ASO, and another source of cadmium sediment impact may be upstream of the ASO.

Chromium concentrations were below its SV in all LVR sediment samples. The chromium concentration of one surface water sample was above its SV from LVR-408, which is located near the upstream end of OU2 (Figure 4.1.4-7). These results suggest that chromium impact in LVR surface water may not be attributable to the Site.

The cobalt concentration of one sediment sample from the LVR was above its SV (near north end of Slag Pile at LVR-405 on Figure 4.1.4-5). These results show that the extent of sediment cobalt impact is limited to LVR-405. Cobalt concentrations were below its SV in all surface water samples from LVR.

LVR sediment copper concentrations were above its SV in 23 samples from the LVR (Table 4.1.4-9) and those samples were collected near and south of the ASO and CSO in the LVR (Figure 4.1.4-5). These results suggest that the ASO, CSO, or the Slag Pile may be sources of copper in LVR sediments. Surface water copper concentrations were above its SV in 21 samples collected from two locations in the LVR (Table 4.1.4-10); these locations were ASO-411 and CSO-410 (Figures 4.1.4-6 and 4.1.4-7). Considering the sediment copper results, the copper surface water results suggest that the ASO and CSO are potential sources of copper impact.

Iron concentrations were below its SV in all LVR sediment samples. Surface water iron concentrations were above its SV in seven samples collected from six locations in the LVR (Table 4.1.4-10). Moving from north to south along the LVR, these locations were as follows (Figure 4.1.4-7):

- Quarry Bridge (reference sampling location upstream of the Site)
- LVR-211
- LVR-209
- LVR-207
- Section_Line_DP
- 5th St. Bridge (see “5thstbridge” in Figure 4.1.4-7)

Since LVR-211, LVR-209, and LVR-207 were recently sampled in 2007, and 2007 sampling locations near the latter two sampling locations (Section_Line_DP and 5th St. Bridge sampled in 1994) show iron concentrations below the SV, surface water iron impact is likely limited to the northern reach of the LVR in OU1.

Sediment lead concentrations were above its SV in 21 samples from the LVR (Table 4.1.4-9) and those samples were collected near and south of the ASO and CSO confluence with the LVR, and along the Slag Pile (Figure 4.1.4-5). These results suggest that potential sources of sediment lead impact are the ASO, CSO, and the Slag Pile. Surface water lead concentrations were above its SV in 15 samples; all were collected from ASO-411 (Tables 4.1.4-10 and 4.1.4-12). These results suggest that the source of surface water lead impact is the ASO.

Sediment mercury concentrations were above its SV in five samples from the LVR (Table 4.1.4-9) and those samples were collected along the entire stretch of LVR sampled in OU1, including areas upstream of the Site (Figure 4.1.4-5). These results show that mercury impact in LVR sediments occurs at discrete locations some of which may be impacted by sources other than the Site. Mercury concentrations were below its SV in all surface water samples from LVR.

Sediment nickel concentrations were above its SV in 20 samples from the LVR (Table 4.1.4-9) and those samples were collected along the entire stretch of LVR sampled in OU1, including locations upstream of the Site (Figure 4.1.4-5). These results show that nickel impact is widespread in LVR sediments including sediment samples from both upstream and downstream of the Site, and that the impact may not be entirely attributable to the Site. Surface water nickel concentrations were above its SV in 28 samples collected from 8 locations in the LVR (Table 4.1.4-10). Moving from north to south along the LVR, these locations included the following (Figures 4.1.4-6 and 4.1.4-7):

- LVR-211
- LVR-207
- ASO-411
- CSO-410
- Section_Line_DP
- LVR-203
- LVR-203
- LVR-201

The highest concentration of nickel was from CSO-410; nickel concentrations decrease with increasing distance downstream of the CSO (Figure 4.1.4-7). These results suggest that a source of nickel impact in the LVR surface water is the CSO. These results also suggest that there may be other sources of nickel impact upstream of OU1 since LVR-211 and LVR-207, upstream of the Site, also show nickel

concentrations above its SV (Figure 4.1.4-7). However, the identification of any additional sources is beyond the scope of this investigation.

Selenium concentrations were below its SV in all sediment samples from OU1. Surface water selenium concentrations were above its SV in 12 samples; all were collected from ASO-411 (Tables 4.1.4-10 and 4.1.4-12). These results suggest that the source of surface water selenium impact is the ASO.

Sediment silver concentrations were above its SV in 22 LVR sediment samples (Table 4.1.4-9), and those samples were collected along the entire stretch of LVR sampled, including locations upstream of the Site (Figure 4.1.4-5). These results show that silver impact is widespread in LVR sediments including samples from upstream and downstream of the Site, and that the impact may not be entirely attributable to the Site. Surface water silver concentrations were above its SV in four samples collected from three locations in the LVR (Table 4.1.4-10). These locations were ASO-411, LVR-405, and LVR-404 (Figures 4.1.4-6 and 4.1.4-7); all were sampled recently in 2009 (Table 4.1.4-12). Based on these results, the source of silver impact could not be discerned. The surface water silver impact is likely limited to the aforementioned sampling locations.

Sediment zinc concentrations were above its SV in 41 samples from the LVR (Table 4.1.4-9), and those samples were collected along the entire stretch of LVR sampled, including locations upstream of the Site (Figure 4.1.4-5). These results show that zinc impact is widespread in LVR sediments and that the impact may not be entirely attributable to the Site. Surface water zinc concentrations were above its SV in 61 samples collected from 13 locations in the LVR (Table 4.1.4-10). The highest concentrations of zinc were from ASO-411 and CSO-410 (Figures 4.1.4-6 and 4.1.4-7). These results suggest that the ASO and CSO are sources of zinc impact in LVR surface water. These results also suggest that there may be other sources of zinc impact upstream of OU1 since one upstream locations (LVR-211) also shows zinc concentrations above its SV (Figure 4.1.4-7).

Cyanide

Sediment cyanide concentrations were above its SV in two samples taken in the early 1990s from the LVR; SSI-X202 and SSI-X203 are near the center and north end of the Slag Pile reach of the LVR (Figure 4.1.4-5). Subsequent samples from the south end, the central portion, and the north end of the Slag Pile reach of the LVR in 2007 could not replicate these results. These results indicate that cyanide impacts in sediments cannot be confirmed. Surface water cyanide concentrations were above its SV in three samples collected in the early 1990s from one location in the LVR near the northern end of the Slag

Pile (Section_Line_DP on Figure 4.1.4-7), and from a reference sampling location upstream of the Site (Quarry Bridge on Figure 4.1.4-7). Subsequent samples from 2007 taken at the central portion and north of the Slag Pile reach of the LVR did not replicate those results. These results indicate that cyanide impact in LVR surface water cannot be confirmed.

VOC

Ten LVR sediment samples from nine locations had acetone concentrations above its SV (Table 4.1.4-13). Moving from north to south along the LVR, the sampling locations included the following (Figure 4.1.4-8):

- LVR-213
- LVR-214
- LVR-209
- SSI-X20
- SSI-X202
- LVR-205
- SSI-X203
- SSI-X204
- LVR-201

Therefore, the horizontal extent of acetone impacts is likely limited to the aforementioned locations. Acetone may be related to a laboratory artifact, rather than the Site impacts. There did not appear to be a pattern for the distribution of the acetone detections.

The measured concentration of 2-butanone (MEK) from LVR-213, a reference sampling location upstream of the Site, was above screening levels. The measured concentrations of all other LVR sediment samples were below screening levels.

VOC concentrations in all LVR surface water samples were below their respective SV (Table 4.1.4-14 and Appendix G-4-25).

SVOC

The concentrations of seven SVOCs were above their respective SVs in LVR sediments. These SVOCs included the following (Table 4.1.4-9):

- Benzo(a)anthracene
- Benzo(a)pyrene
- Bis(2-ethylhexyl)phthalate
- Chrysene
- Fluoranthene
- Phenanthrene
- Pyrene

Five of 16 LVR sediment samples had SVOC concentrations above their respective SV. Moving from north to south along the LVR, these samples were from the following locations (Figure 4.1.4-9):

- LVR-213
- SSI-X202
- LVR-205
- SSI-X203
- SSI-X204

SSI-X202 is located north of the Slag Pile near the inflowing tributary from the ASO, and the remaining three locations are along the Slag Pile reach of the LVR (Figure 4.1.4-9). Subsequent sampling along the Slag Pile reach of the river did not detect SVOCs above the SVs. The SVOC concentrations in samples upstream and downstream of these locations are below their respective SVs, the horizontal extent of SVOC impact cannot be confirmed in the LVR sediments east of the Slag Pile and may have attenuated since the initial sampling in the 1990s (Figure 4.1.4-9). SVOC concentrations in all LVR surface water samples were below their respective SVs.

PCBs

The concentrations of three PCBs were above their respective SVs in LVR sediments; the PCBs were Aroclors 1242, 1254, and 1260 (Table 4.1.4-9). Five of 16 LVR sediment samples had PCB concentrations above their respective SVs (Figure 4.1.4-10). Moving from north to south along the LVR, these samples were from the following locations (Figure 4.1.4-10):

- ISA-X204
- SSI-X201
- ISA-X202
- ISA-X203
- SSI-X204

All of the aforementioned samples are located north of the Slag Pile, except SSI-X204 which is located on the southern end of the Slag Pile (Figure 4.1.4-10). All three PCBs have the highest concentrations at ISA-X204. These results suggest that this location is a PCB source since ISA-X204 is the upstream of the other locations (Figure 4.1.4-10). However, all PCB samples above their respective SVs were collected in 1991 and 1993. PCB samples collected from adjacent locations in 2007 had concentrations below the analytical method detection limit. These results suggest that the horizontal extent of PCB impact may be limited or no longer present in the LVR, and PCB impacts may have attenuated since 1993. PCB concentrations in all LVR surface water samples were below their respective SVs (Appendix G-4-27).

Pesticides

The concentrations of seven pesticides were above their respective SVs in LVR sediments. The pesticides included the following (Table 4.1.4-9):

- 4,4'-DDD
- 4,4'-DDT
- Alpha-chlordane
- Dieldrin
- Endrin
- Endrin aldehyde
- Gamma-chlordane

Four of 19 LVR sediment samples had pesticides concentrations above their respective SVs (Table 4.1.4-17). Moving from north to south along the LVR, these samples were ISA-X205, ISA-X204, ISA-X202, and ISA-X203; all samples are located north of the Slag Pile (Figure 4.1.4-11). Like PCBs, all seven pesticides have the highest concentrations at ISA-X204 (Figure 4.1.4-11). Also like PCBs, all pesticides samples above their respective SVs were collected in 1993. Pesticides samples collected from adjacent locations in 2007 had concentrations below the analytical method detection limit. These results suggest that the horizontal extent of pesticides impacts is likely limited or no longer present in the LVR, and pesticides impacts may have attenuated since 1993. Pesticides concentrations in all LVR surface water samples were below their respective SV (Appendix G-4-28).

Collocation

COIs measured above SVs in LVR sediment samples include metals, cyanide, VOCs, SVOCs, pesticides, and PCBs (Figures 4.1.4-5 to 4.1.4-11). The description of the collocation of various COIs is for the purpose of investigating whether there are areas that appear to be impacted by different COI groups and may require differing remedial technologies. Collocated sediment exceedances may indicate source areas or locations where sediment is accumulating from different sources.

Sediments were sampled from several locations within the LVR. The most broadly sampled locations were the south end of the Slag Pile and in the LVR.

Two VOCs were measured in LVR sediment samples—acetone and 2-butanone (MEK) (Table 4.1.4-13). Acetone was detected in numerous samples from the LVR; 2-butanone was detected in a sample from LVR-213, a reference sampling location upstream of the Site (Figure 4.1.4-8). Acetone may be related to a laboratory artifact, rather than the Site impacts. There did not appear to be a pattern for the distribution of the acetone detections.

Within the LVR sediment samples, metals were present above SVs throughout the length sampled (Figure 4.1.4-5). SVOCs were also fairly broadly detected, but less so than the metals (Figure 4.1.4-9).

Locations with SVOC exceedances are consistently downstream of the location where the ASO is tributary to the LVR. These results suggest that the ASO is a source of SVOC impacts.

PCBs were present in LVR sediments. The exceedances measured were in five samples, four of which were at or downstream from the ASO outfall into the LVR while one is upstream of that location (Figure 4.1.4-10).

Pesticides were present in four samples from the LVR. Two of those locations were upstream of the ASO outfall, and two were immediately at the confluence (Figure 4.1.4-11). PCBs and pesticides appear to have historically been collocated at ISA-X204.

A number of COIs are present at the confluence of the ASO outfall and the LVR. In addition to metals which are in most samples, that area has exhibited exceedances of pesticides, and PCBs, as well as numerous SVOC exceedances in the reach of the LVR downstream from that point. The collocation or close association suggests a potential source for these COIs may be the ASO discharge.

The COIs measured above SVs in surface water at OU1 were limited to metals (Figure 4.1.4-6 and 4.1.4-7). The exceedances were measured in both dissolved and total fraction analyses. The ubiquitous extent of the metals exceedances, and the absence of other COI exceedances precludes the evaluation of collocation of impacts in the surface water samples.

4.1.7 OU1 Air Results

Personal and area real-time air samples were collected in accordance with the Health and Safety Plan during the trenching activities in the Slag Pile Area. The locations of the trenching activities are shown in Figure 2.1.1-2. The analytical results for air sampling from OU1 are summarized in Table 4.1.7-1.

All air sampling results for OU1 were below screening limits for arsenic, lead, and asbestos. Arsenic concentrations were above analytical detection limits in samples from the upwind side of trench 8, and both the upwind and downwind sides of trench 9. The highest arsenic concentration was 0.0209 microgram per cubic meter ($\mu\text{g}/\text{m}^3$) and was measured on the downwind side of trench 8 (Table 4.1.7-1). Lead concentrations were above analytical method detection limits in all OU1 air samples. Similar to arsenic, the highest lead concentrations ($0.537 \mu\text{g}/\text{m}^3$) was measured on the downwind side of trench 8 (Table 4.1.7-1).

Asbestos concentrations were above analytical method detection limits in all OU1 air samples. The highest asbestos concentration was 6.39×10^{-4} fibers per milliliter (fibers/mL) and was measured in the composite sample from the upwind locations of trenches 1 and 3 (Table 4.1.7-1).

4.2 OU2 RESULTS

SulTRAC collected surface and subsurface soil, building material, pile, groundwater, surface water, and air samples in order to investigate the nature and extent of contamination at and around the Matthiessen and Hegeler Zinc Company Site. The samples were analyzed for various combinations of total metals, cyanide, VOCs, SVOCs, PCBs, pesticides, and asbestos as described in [Section 2.0](#) of this RI report.

This section compares the data collected from OU2 on- and off-site areas to a screening metric based on the risk assessment screening levels approved by the regulatory agencies presented in Attachment 4, Revision 1, of the Consensus Document (Geosyntec and SulTRAC 2008). As discussed in [Section 4.0](#), for the nature and extent of contamination evaluation in this section, the risk assessment screening levels from the Consensus Document have been modified and are referred to as SVs. Sections [7.0](#) and [8.0](#) of this RI report, the HHRA and ERA summaries, respectively, and the HHRA and ERA (Appendix RA) describe and use the risk assessment screening levels. The SVs summarized below were used for the nature and extent of contamination evaluation for the various matrices sampled at OU2.

- Soil, building material, and pile sample results were compared to the December 2009 US EPA IRSLS and RRSLS for soils.
- Groundwater sample results were compared to the December 2009 US EPA MCLs and US EPA Tap Water RSLs.
- Surface water results were compared to the most conservative value from the following sources:
 - IWQS based on general use and the protection of human health
 - IEPA-derived Water Quality Criteria for Human Health
 - NRWQC for ingestion of aquatic organisms

If a value was not available from any of the sources listed above, the US EPA Tap Water RSLs were used.

- Soil and building material TCLP sample results were compared to the regulatory levels at 40 CFR §261.24.
- Soil SPLP sample results were compared to the regulatory levels at 40 CFR §261.24 and the US EPA groundwater MCLs. If groundwater MCLs were not available for a particular analyte, then the US EPA Tap Water RSLs were used.

The Final RI report was prepared using the December 2009 US EPA RSLs. As discussed and agreed upon with the US EPA, this Final RI report continued to use the December 2009 US EPA RSLs regardless of any more recent updates to the RSLs.

In December 2009, the US EPA IRSRLs and RRSRLs were updated and the soil RSLs for total chromium and thallium were removed. Therefore, for the thallium soil, slag, building material, and pile sample results, the April 2009 US EPA RSLs were used. For total chromium, although there are no December 2009 RSLs, there are speciated RSLs for trivalent and hexavalent chromium. However, no soil samples were collected for speciated chromium results. Therefore, the total chromium soil, slag, building material, and pile sample results will be used and compared to the April 2009 US EPA RSLs.

Duplicate samples were collected for all matrices as described in the Phase I and Phase II SAPs (SulTRAC 2007 and 2008a). To describe the nature and extent of contamination at OU2, the associated tables and figures present both the duplicate and original sample results. However, the text and statistical data presented in this section only consider the maximum value of an analyte in the original or duplicate sample. Risk assessment statistical handling of duplicate sample results was based on the set of procedures outlined in the Consensus Document (Geosyntec and SulTRAC 2008), and these procedures were applied to Sections [7.0](#) and [8.0](#) of this RI report, the HHRA and ERA summaries, respectively, and the HHRA and ERA (Appendix RA).

The OU2 investigation areas ([Section 4.2.1](#)), soil results ([Section 4.2.2](#)), building material results ([Section 4.2.3](#)), pile results ([Section 4.2.4](#)), groundwater results ([Section 4.2.5](#)), surface water results ([Section 4.2.6](#)), and air results ([Section 4.2.7](#)) are discussed below. In the sections discussing the sampling results, the terms “impact,” “impacts,” and “impacted” media and areas refer to concentrations that exceed one or more of the SVs.

4.2.1 OU2 Investigation Areas

To describe the nature and extent of contamination, OU2 was divided into the following six investigation areas:

- Investigation Area 1: Building 100
- Investigation Area 2: Rolling Mill
- Investigation Area 3: Former Main Industrial Area
- Investigation Area 4: North Area/Northeast Periphery Area

- Investigation Area 5: Residential Area/Off-site Area
- Groundwater Investigation Area: WBZ1 and WBZ2

The following sections describe each area. Table 4.2.1-1 presents useful information regarding current and historical buildings and uses within the boundaries of OU2 as discussed throughout this section. Figure 4.2.1-1 shows the former and current building locations at OU2, and Figures 4.2.1-2 and 4.2.1-3 show the five different investigation areas at OU2. Table 3.3.3-1 from [Section 3](#) presents the WBZ1 and WBZ2 designations for each MW and piezometer at OU2.

4.2.1.1 Investigation Area 1: Building 100

For purposes of this RI report, Investigation Area 1, Building 100, is defined as an area measuring about 435 by 845 ft shown as the blue-shaded area in Figure 4.2.1-2. Investigation Area 1 measures about 365,000 square feet (ft²) and includes the existing Building 100, the former thaw house, and the former scale house. Building 100 measures about 5,610 ft² and is constructed of brick and concrete. Building 100 was used as a locomotive repair shop and contained three tracks for locomotive repair work. Currently, Building 100 is slightly dilapidated and used for dry storage. As recently as two years ago, Building 100 has been used to store backer-board and from the fall of 2008, Building 100 has been used to store a tractor trailer bed. The former thaw house was used to thaw zinc ores brought to OU2 by railroad using coal heat. The exact use of the scale house is uncertain, however, it is presumed that it was used to measure the weight of in-coming and out-going railcars. During investigative sampling activities at OU2, the main COIs discovered at Investigation Area 1 included metals and PCBs.

4.2.1.2 Investigation Area 2: Rolling Mill

For the purposes of this RI report, Investigation Area 2, Rolling Mill, is defined as the southernmost area of OU2 shown as an orange-shaded area on Figure 4.2.1-2. Investigation Area 2 measures about 435,000 ft² and includes the existing Rolling Mill building and a main office building. Investigation Area 2 extends north from the southern OU2 boundary about 570 ft and about 1,000 ft east from the western OU2 boundary. Historically, the Rolling Mill building produced zinc sheets until 1960 and then generated metal blanks for pennies until 2000. From 2005 to 2008, the Rolling Mill building was leased to a company which used the Rolling Mill building to store backer-board, and the current owner, Fred Carus, has been attempting to resurrect the operational capacity of several of the zinc sheet rolling machines in the Rolling Mill building. During investigative sampling activities at OU2, the main COIs discovered at Investigation Area 2 included metals, VOCs, and SVOCs.

4.2.1.3 Investigation Area 3: Former Main Industrial Area

For the purposes of this RI report, Investigation Area 3, Former Main Industrial Area, is defined as the central area of OU2 shown in white on Figure 4.2.1-2. Investigation Area 3 occupies about 62 acres (2,702,260 ft²) and includes the shallow waste pile of sinter and slag heterogeneously deposited throughout the area as well as most of the former structures in the central portion of OU2. Most of the structures have been demolished, and foundations or partial remnants of former buildings remain. Historically, raw materials such as zinc ore and various grades of coal were transported to OU2 to smelt zinc. The smelting process included a furnace that used producer gas as fuel, and any sulfur dioxide generated was recovered and converted into sulfuric acid and stored in on-site tanks. Investigation Area 3 also had an ammonium sulfate fertilizer plant that operated for a few years during the early 1950s. Coal mining occurred on OU2 until 1937, and two mining shafts (one vertical and one horizontal) currently remain. During investigative sampling activities at OU2, the main COIs discovered at Investigation Area 3 included metals.

4.2.1.4 Investigation Area 4: North Area/Northeast Periphery Area

For the purposes of this RI report, Investigation Area 4, North Area/Northeast Periphery Area, is defined as the green-shaded area on Figure 4.2.1-2. Investigation Area 4 occupies about 40 acres (1,757,930 ft²) and includes the former ICRR. During investigative sampling activities at OU2, the main COIs discovered at Investigation Area 4 included metals.

4.2.1.5 Investigation Area 5: Residential Area/Off-site Area

For the purposes of this RI report, Investigation Area 5, Residential Area/Off-site Area, is defined as the area within the yellow boundary on Figure 4.2.1-3. The residential area contains residences west, northwest, and southwest of the Matthiessen and Hegeler Zinc Company Site extending about 0.75 mile north of the northernmost OU2 boundary to about 0.47 mile south of the southernmost OU1 boundary and extending about 1.3 miles west of the westernmost OU2 boundary. The off-site non-residential sampling locations are along about 3,280 ft of the eastern bank of the LVR. The Off-site Area extends from the southern property boundary of OU1 north along the LVR approximately 3,280 ft, and extends at most, about 520 ft west of the eastern boundary of the Matthiessen and Hegeler Zinc Company Site. Investigative sampling activities at Investigation Area 5 included only metals.

4.2.1.6 Groundwater Investigation Areas: WBZ1 and WBZ2

For the purposes of this RI report, the OU2 groundwater results are discussed with respect to the WBZ from which each sample was collected. SulTRAC has defined each OU2 well as belonging to either: 1) WBZ1, the shallow WBZ consisting of unconsolidated fill material (both natural and anthropogenic); or 2) WBZ2, the deeper WBZ consisting of the underlying bedrock formation (shale and/or limestone). Figure 4.2.1-4 shows MWs and piezometers screened in each WBZ. [Section 3.3.3](#) of this RI report discusses the WBZ designations in detail, and Table 3.3.3.1 lists the MWs, piezometers, and their respective WBZ designations. During investigative sampling activities in WBZ1 and WBZ2, the main COIs discovered in groundwater included metals and VOCs.

4.2.2 OU2 Soil Results

Soil samples were collected during both Phase I and Phase II field investigations using two methods: soil boring advancement using a Geoprobe® or hand auger, and surface soil grab sampling using a bulb planter or trowel with XRF screening. Figures 4.2.2-1a and 4.2.2-1b show all soil sampling locations for OU2 Investigation Areas 1 through 4 and OU2 Investigation Area 5, respectively.

Soil Boring Samples:

SulTRAC advanced a total of 257 borings within the boundaries of OU2 during Phase I and Phase II investigation activities. An additional 30 off-site soil borings were advanced within a 3-mile radius of the Matthiessen and Hegeler Zinc Company Site. These soil borings were designated as background soil sampling locations. Surface and subsurface soil samples were collected from most of the 257 on-site and background soil borings at two depth intervals per boring. All surface soil samples were collected from 0 to 2 ft bgs. Subsurface samples were collected from the 2-ft surface interval with the highest apparent contamination based on field observations and PID screening results. When field screening results and observations did not establish an interval for subsurface sampling, samples were then collected from the shallowest of the following: above the water table, above bedrock, or by default, the 8- to 10-ft-bgs interval. Additionally, 10 soil borings (SB401 through SB410) from the Phase II soil boring activities were advanced to investigate the PCB contamination detected around Building 100. Subsurface soil samples from these 10 soil borings were collected from a “clean” 2-ft interval below 10 ft bgs based on PCB field test kit results or from 2-ft interval above refusal.

For the background borings, as discussed in [Section 2.3](#), two background investigations were conducted in December 2009 and December 2010. In December 2009, SulTRAC advanced 18 background soil

borings to collect surface and subsurface soil samples from two depth intervals per boring. For these 18 background soil borings, surface soil samples also were collected from 0- to 2-ft bgs and subsurface soil samples were collected from 8- to 10-ft bgs or above the water table if the water table was shallower than the 8- to 10-ft bgs interval. In December 2010, SulTRAC advanced another 12 background soil borings, located at a further distance from the Site than the December 2009 event, to collect surface and subsurface soil samples from two depth intervals per boring. For these 12 background soil borings, surface soil samples were collected from 0 to 6 inches bgs and subsurface soil samples were collected from a 2-ft interval between 6 inches bgs and 10 ft bgs. However, as discussed in [Section 2.3](#), results from the second background investigation are not included in this RI report.

During the Phase I soil boring advancement, SulTRAC collected 373 soil samples from 197 soil borings. The samples from the Phase I soil borings were analyzed for total metals, cyanide, VOCs, SVOCs, PCBs, and pesticides. All surface and subsurface soil samples classified as fill material also were analyzed for asbestos (Table 4.2.2-1a).

During the Phase II soil boring advancement, SulTRAC collected 122 soil samples from 60 soil borings. The soil samples were analyzed for various combinations of total metals, cyanide, VOCs, SVOCs, PCBs, pesticides, TCLP and SPLP metals, and asbestos, depending on soil boring location (Table 4.2.2-1a). Sampled analyte group details are discussed in [Section 2.2.1.2](#) of this RI report and summarized in Table 2.2.1-1. Also during Phase II activities in December 2009, SulTRAC advanced background soil borings in the LaSalle, Peru area to obtain site- or area-specific metals, cyanide, and SVOC concentrations for native soil or soil not potentially affected by past operations at the Matthiessen and Hegeler Zinc Company Site. A total of 32 soil samples were collected from 18 soil borings. (As discussed in [Section 2.3](#) and Appendix RA-2-1, in December 2010, 24 additional background soil samples were collected from 12 borings. However, those results are not included in this RI report.) The soil samples were analyzed for total metals, cyanide, and SVOCs. Several statistical methods were used to calculate metals concentrations for the background soil samples which are referred to as BTVs. BTVs are single-point background thresholds that represent an upper plausible limit for the background distributions of individual metals and were calculated using the background data set of at least eight detected results for each metal (Appendix RA-2). BTVs were not developed for analytes with less than eight analytical detections. These included the nutrient metals, cyanide, selenium, silver, and thallium. BTVs were not developed for SVOC compounds because there were not enough analytical detections. The risk assessment portion of the RI report (Appendix RA-2) presents the statistical method and calculations used to calculate the BTV concentrations. Surface and subsurface soils have specific BTVs and are presented

on the tables for the metals results (Tables 4.2.2-1a and 4.2.2-1b).

All soil boring sample identification numbers have the prefix “SB” before the three-digit sampling location number, followed by “A” for surface samples and “B” for subsurface samples (Figure 4.2.2-1a). The Phase II soil sample identification numbers also have a two-digit number indicating the year the sample was collected (Figure 4.2.2-1a).

Surface Soil Grab and XRF-Screened Samples:

During the Phase I and Phase II RI field activities, 198 residence yards, 161 on-site locations, and 20 off-site, east of the LVR, locations were surface soil sampled. The residential surface soil samples consisted of a five-point composite sample from 0 to 6 inches bgs and when warranted, additional surface composite samples were collected from 6 to 12 inches bgs. At the on- and off-site locations all samples consisted of a grab sample from 0 to 6 inches bgs. All listed sampling locations were also screened using an XRF analyzer for various metal compounds, except for 24 residential yards sampled during March 2010 Phase II activities. Subsets of XRF-screened soil samples were typically sent to a CLP laboratory for further analysis. Specifics are discussed below.

The Phase I residential XRF screening event was conducted April 2007, at 136 residences by US EPA FIELDS team along with its subcontractor, Weston, with a total of 180 soil samples collected and XRF-screened (Figure 4.2.2-1b). All soil samples were screened for four metals: arsenic, cadmium, lead, and zinc. Thirty-seven screened samples (20 percent) were submitted to the CLP laboratory for total metals analysis. The soil samples submitted to the laboratory were used to correlate the XRF results to the laboratory analytical results. The US EPA FIELDS team used linear regression and regression diagnostics to calculate the “best fitting” linear relationship between XRF results and the corresponding laboratory results. The statistically calculated “best fitting” linear relationship then was used to adjust all of the XRF results for each screened sample. Appendix S-9 presents details regarding the methods used to adjust the XRF results. For Phase I residential soil sampling, linear relationships were calculated for lead and zinc XRF screening results. Linear relationships were not calculated for arsenic and cadmium because there were not enough detected results to allow the calculation of linear relationships. The data presented for these residential surface soil samples are the adjusted lead and zinc results for the XRF-screened samples and the 37 soil samples submitted to the CLP laboratory for total metals analysis (Table 4.2.2-1b). Phase I residential soil sample identification numbers (April 2007 event) have the prefix “MHS”, the three-digit number, followed by either “FY” for front yard, “BY” for back yard, or “SY” for side yard, followed by either “1” for a surface soil sample, 0 to 6 inches bgs, or “2”, 6 to 12 inches

bgs(Figure 4.2.2-1b and Table 4.2.2-1b).

During Phase II RI field activities, US EPA FIELDS team and SulTRAC sampled 161 on-site, 20 off-site (east of the LVR), and 62 residential surface soil locations (Figures 4.2.2-1a and 4.2.2-1b). All soil samples from the on-site, off-site, and 38 of the residential locations were XRF-screened for five metals: arsenic, cadmium, lead, mercury, and zinc. Of the 161 on-site screened soil samples, 50 samples were submitted to the CLP laboratory for total metals analysis. The 50 on-site soil samples submitted to the CLP laboratory were used to correlate the XRF results to the laboratory analytical results as described above. For Phase II on-site sampling activities, linear relationships were calculated for arsenic, cadmium, lead, and zinc XRF screening results (Appendix S-9). Linear relationships were not calculated for mercury because of the lack of variability (range of values) in the laboratory-measured mercury concentrations compared to the XRF screening results for mercury. The data presented for the on-site XRF samples are the adjusted arsenic, cadmium, lead, and zinc concentrations. XRF mercury results are not presented. The laboratory results for the 50 on-site surface soil samples are presented instead of the adjusted XRF screening results. The Phase II on-site soil sample identification numbers have the prefix “poly” followed by the numbers 1 through 6 before a three-digit sampling location number. “Poly” is the shortened form of “polygon,” which indicates the numbered polygon grid (as shown in Figure 2.2.1-3) from which the sample was collected (Figure 4.2.2-1a and Table 4.2.2-1a).

All off-site (east of the LVR) XRF-screened soil samples (20 samples) were submitted to the CLP laboratory for total metals analysis. Therefore, the data presented for these 20 samples are the laboratory results for all metals (Table 4.2.2-1b). The off-site (May 2009) surface soil samples collected from the eastern bank of the LVR have “408” followed by a three-digit sample number (Figure 4.2.2-1b and Table 4.2.2-1b).

During the Phase II investigation, September 2009, the US EPA FIELDS team XRF-screened soil at 38 different residences and 47 sampling locations (Figure 4.2.2-1b). All 2009 Phase II residential XRF-screened samples were submitted to the CLP laboratory for total metals analysis. Therefore, the data presented for these 47 soil grab samples are the laboratory results for all metals (Table 4.2.2-1b). The residential soil sample identification numbers from the September 2009 event are indicated by “MH2” followed by “S” and a three-digit sample number, the yard designation as discussed above, followed by either “0-6” or “6-12” to designate the sampled interval (Figure 4.2.2-1b and Table 4.2.2-1b).

In March 2010, SulTRAC collected 24 surface soil samples from either the front or back yard of 24 different residences. All soil samples were not XRF-screened and directly submitted to the CLP

laboratory for total metals analysis. Therefore the data presented for these 24 samples are the laboratory results for all metals (Table 4.2.2-1b). The residential soil sample identification numbers for the March 2010 event are indicated by a four letter prefix representing the first four letters of the sampled residential street name, followed by the first three digits of the numerical address (Figure 4.2.2-1b and Table 4.2.2-1b).

All surface and subsurface soil samples sent to a CLP laboratory were analyzed using the US EPA methods listed in Table 2.2.1-3 and in the Phase I and II SAPs (SulTRAC 2007 and 2008a). QC samples (field duplicates and MS/MSD samples) also were collected for soil samples submitted to the CLP laboratory for analysis as described in the Quality Assurance Project Plan (QAPP) (SulTRAC 2008d).

Tables 4.2.2-1 through 4.2.2-8 present the detected analytical results for total metals and cyanide, VOCs, SVOCs, PCBs, pesticides, asbestos, TCLP metals, and SPLP metals, respectively. The soil sample results were compared to the US EPA RSLs for all analytes except asbestos, TCLP metals, and SPLP metals. The RSLs are discussed in detail in [Section 4.2](#). The asbestos results are discussed as either detected or not detected. TCLP metals results were compared to the 40 CFR §261.24 regulatory levels. SPLP metals results were compared to both the 40 CFR §261.24 regulatory levels as well as the US EPA groundwater MCLs. If groundwater MCLs did not exist for a particular analyte, then the US EPA Tap Water RSLs were used. In the following sections, when the SPLP metals results were compared to groundwater standards, they are collectively referred to as the groundwater screening values (GWSV). The metals were also compared to the surface and subsurface BTVs. BTVs were less than both of the RSLs except for arsenic and manganese. The surface and subsurface BTVs for arsenic were greater than both the RRSL and IRSL. Therefore, all soil arsenic results were compared to the surface and subsurface BTVs. The manganese surface BTV was below both RSLs but the subsurface BTV was greater than the RRSL and below the IRSL. Therefore, the manganese subsurface results were compared to all three values, the RRSL, IRSL, and the subsurface BTV. All of the surface and subsurface BTVs are presented in the metals results table (Table 4.2.2-1a).

Figures 4.2.2-2a through 4.2.2-18b display the results and impacted area for the following analytes: five individual metals (arsenic, cadmium, lead, mercury, and zinc), “other metals” and cyanide, VOC, SVOC, PCB, pesticides, asbestos, and TCLP and SPLP metals. Surface and subsurface results are plotted separately on Figures 4.2.2-2a through 4.2.2-18b. The “[contaminant] Results” figures show color coded results at each sample location to denote if an analyte (or group of analytes) was non-detect, was detected but at concentrations less than RSLs, was detected at concentrations that exceed RRSL, and/or exceed IRSL. A subsurface soil results figure was not prepared for asbestos because asbestos was not detected in

any subsurface soil samples. The “Arsenic Results” figures for surface and subsurface soils show color coded results to denote if the sample results were detected at concentrations exceeding both RSLs and the BTV in red and concentrations that would have exceeded the RRLs or IRLs but are below the BTV in gray.

In addition to the “[contaminant] Results” figures, separate “Extent of [Contaminant] Impact” figures were created for those individual metals and set of compounds that exceeded the *IRSL* at one or more sample locations at OU2. The “Extent of [Contaminant] Impact” figures show the extents of greatest impact in the surface and subsurface soils. Both residential and IRL exceedances are presented on the impact figures, however, the extent of impact boundary line on each figure only includes the IRL exceedances.

One exception to the above described impact figure presentation is for the residential/off-site area, in which the impacted areas presented in the “Extent of [Contaminant] Impact” figures are defined as the areas where concentrations of a metal exceeded the *RRLs*. Another exception is the “Extent of Arsenic Impact” figures, where the impact boundary line includes BTVs that exceed the *RRL* and *IRL*. Compounds that did not exceed the *IRL* do not have “Extent of [Contaminant] Impact” figures. Asbestos does not have an “Extent of [Contaminant] Impact” figure because the results are not compared to a regulatory screening criteria and are only discussed as detected or not detected results. The extent of impact boundary line in each figure was chosen approximately halfway between the sampling location where the result exceeded the *IRL* and the sampling location where the result was below the *IRL*. A dashed line shows the inferred extent of impacted soil based on known data and site conditions. Note that the impacted areas presented in the “Extent of [Contaminant] Impact” figures may include some sampling locations where results did not exceed the *IRLs*; however, these locations are included in the impacted area because of known physical site conditions that warrant inclusion.

The following sections discuss soil analytical results for OU2 Areas 1 through 5.

4.2.2.1 Investigation Area 1: Building 100

A total of 68 soil samples were collected from Investigation Area 1, Building 100 (Figure 4.2.2-1a). Of the 68 soil samples, there were 40 total surface soil samples, 28 surface soil boring and 12 surface grab samples, and 28 were subsurface soil boring samples. The surface and subsurface soil total metals and cyanide, VOC, SVOC, PCB, pesticides, asbestos, TCLP metals, and SPLP metals results for Investigation Area 1 are summarized below, followed by a summary of the Investigation Area 1 results.

Metals and Cyanide

Of the 40 (28 soil boring and 12 grab) surface soil samples collected from Investigation Area 1, 28 surface soil boring samples were analyzed for total metals and cyanide. Twelve surface soil samples from Investigation Area 1 were screened using the XRF analyzer for arsenic, cadmium, lead, and zinc. Of the 12 surface soil samples screened using the XRF analyzer, 2 were submitted to the CLP laboratory for total metals and cyanide analysis. All 28 subsurface soil boring samples collected from Investigation Area 1 were analyzed for total metals and cyanide. Tables 4.2.2-1a and 4.2.2-1b summarize the detected metals and cyanide results for the soil boring and XRF-screened samples, respectively. Table S-10 in Appendix S-10 presents the full set of metals and cyanide results for the soil boring samples. Analytical results are discussed for six individual analyte groups: arsenic, cadmium, lead, mercury, zinc, and cyanide. In addition, analytical results for other analytes detected also are discussed under a general category called “other metals.” Because of the large number of analytical detections and concentrations exceeding the US EPA RSSL and IRSL, results for the individual metal analytes are discussed below based on the number of RSL exceedances.

Arsenic

All 40 surface soil and all 28 subsurface soil samples collected from Investigation Area 1 were analyzed by the CLP laboratory or screened using the XRF analyzer for arsenic (Figures 4.2.2-2a and 4.2.2-2b). The RSSL and IRSL for arsenic are 0.39 and 1.6 mg/kg, respectively. The BTVs for arsenic in surface and subsurface soils are 10.7 and 12.44 mg/kg, respectively. Both BTVs were above both the RSSL and IRSL.

- Twenty-nine surface soil sample results (73 percent) exceeded both the RSSL and IRSL. Twenty-three surface soil sample results (58 percent) exceeded the BTV.
- All 28 subsurface soil sample results (100 percent) exceeded the RSSL, and 26 subsurface soil sample results (93 percent) exceeded the IRSL. Thirteen subsurface soil sample results (46 percent) exceeded the BTV.
- The maximum detected surface soil arsenic concentration was 217 mg/kg in sample SB410A-08 composed of a combination of slag, sinter, and fill material.
- The maximum detected subsurface soil arsenic concentration was 257 mg/kg in sample SB211B collected from 8 to 10 ft bgs composed of clay.

Within Investigation Area 1, a total of 68 soil samples were analyzed or screened for arsenic, of which 88 percent exceeded at least one RSL. Arsenic in soil exceeded the BTV in only 53 percent of the total samples in Investigation Area 1. Arsenic exceeded the BTV more in surface soils than subsurface soils and was present in both fill and clay within Investigation Area 1. Investigation Area 1 is adequately delineated for both surface and subsurface soils. Figures 4.2.2-2c and 4.2.2-2d show the surface and subsurface extents of arsenic-impacted soil, respectively.

Cadmium

All 40 surface soil and all 28 subsurface soil samples collected from Investigation Area 1 were analyzed by the CLP laboratory or screened using the XRF analyzer for cadmium (Figures 4.2.2-3a and 4.2.2-3b). The RSSL and IRSL for cadmium are 70 and 800 mg/kg, respectively. The BTVs for cadmium in surface and subsurface soils are 7.1 and 4.68 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- Thirteen surface soil sample results (33 percent) exceeded the RSSL. No surface soil sample results exceeded the IRSL.
- One subsurface soil sample result (4 percent) exceeded the RSSL. No subsurface soil sample results exceeded the IRSL.
- The maximum detected surface soil cadmium concentration was 292 mg/kg in sample SB015A composed of sinter and slag material.
- The maximum detected subsurface soil cadmium concentration was 247 mg/kg in sample SB405B-08 collected from 22 to 24 ft bgs composed of clay.

Within Investigation Area 1, a total of 68 soil samples were analyzed or screened for cadmium, of which 20 percent exceeded at least one RSL. Most exceedances were detected in samples of slag, sinter, and fill materials except for a few exceedances in samples of native material. Cadmium is more prevalent in surface soil than in subsurface soil at Investigation Area 1. Cadmium has been horizontally defined to the OU2 boundary within Investigation Area 1 and adequately defined vertically. No surface or subsurface soils exceeded the IRSLS for cadmium within Investigation Area 1.

Lead

All 40 surface soil and all 28 subsurface soil samples collected from Investigation Area 1 were analyzed by the CLP laboratory or screened using the XRF analyzer for lead (Figures 4.2.2-4a and 4.2.2-4b). The

RRSL and IRSL for lead are 400 and 800 mg/kg, respectively. The BTVs for lead in surface and subsurface soils are 103 and 66.1 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- Twenty-five surface soil sample results (63 percent) and twenty surface soil sample results (50 percent) exceeded the RRSL and IRSL, respectively.
- Thirteen subsurface soil sample results (46 percent) and twelve subsurface soil sample results (43 percent) exceeded the RRSL and IRSL, respectively.
- The maximum detected surface soil lead concentration was 14,500 mg/kg in sample SB016A composed of slag and fill materials.
- The maximum detected subsurface soil lead concentration was 13,200 mg/kg in sample SB409B-08 collected from 20 to 21 ft bgs composed of native clay material.

Within Investigation Area 1, a total of 68 soil samples were analyzed or screened for lead, of which 56 percent exceeded at least one RSL. In most soil borings, if the surface soil sample result exceeded at least one RSL for lead, the subsurface soil sample result also exceeded at least one RSL for lead. Most exceedances were detected in samples of slag, sinter, and fill materials with few exceedances in samples of native material. The lead exceedances generally were located around Building 100 in Investigation Area 1. Lead has been horizontally and vertically defined to the OU2 boundary within Investigation Area 1. Figures 4.2.2-4c and 4.2.2-4d show the surface and subsurface extents of lead-impacted soil, respectively.

Mercury

Thirty surface soil and all twenty-eight subsurface soil samples collected from Investigation Area 1 were analyzed by the CLP laboratory for mercury (Figures 4.2.2-5a and 4.2.2-5b). The RRSL and IRSL for mercury are 5.6 and 34 mg/kg, respectively. The BTVs for mercury in surface and subsurface soils are 1.32 and 1.33 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- Three surface soil sample results (10 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- No subsurface soil sample results exceeded the RRSL or IRSL.
- The maximum detected surface soil mercury concentration was 9.7 mg/kg in sample poly_5_008 composed of brown silty soil with gravel sinter materials.

- The maximum detected subsurface soil mercury concentration was 0.68 mg/kg in sample SB005B collected from 6 to 8 ft bgs composed of slag material.

Within Investigation Area 1, a total of 58 soil samples were analyzed or screened for mercury, of which only 5 percent exceeded the RSSL. The samples exceeding the mercury RSLs consisted of surface soil composed of slag, sinter, and fill materials. The exceedances were not localized in any particular area and have been adequately delineated both horizontally and vertically. No surface or subsurface soils exceeded the IRSLS for mercury within Investigation Area 1.

Zinc

All 40 surface soil and all 28 subsurface soil samples collected from Investigation Area 1 were analyzed by the CLP laboratory or screened using the XRF analyzer for zinc (Figures 4.2.2-6a and 4.2.2-6b). The RSSL and IRSLS for zinc are 23,000 and 310,000 mg/kg, respectively. The BTVs for zinc in surface and subsurface soils are 1,310 and 740 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- Ten surface soil sample results (25 percent) exceeded the RSSL. No surface soil sample results exceeded the IRSLS.
- Two subsurface soil sample results (7 percent) exceeded the RSSL. No subsurface soil sample results exceeded the IRSLS.
- The maximum detected surface soil zinc concentration was 211,000 mg/kg in sample SB252A (the duplicate sample of SB008A) composed of sinter and slag.
- The maximum detected subsurface soil zinc concentration was 49,600 mg/kg in sample SB405B-08 from 22 to 24 ft bgs composed of native clay material.

Within Investigation Area 1, a total of 68 soil samples were analyzed or screened for zinc, of which 18 percent exceeded at least one RSL. The samples exceeding the zinc RSLs consisted of surface soil composed of slag, sinter, and fill materials. The exceedances generally were located around Building 100 in Investigation Area 1. Zinc has been horizontally and vertically defined. No surface or subsurface soils exceeded the IRSLS for zinc within the OU2 boundary. Therefore, surface and subsurface zinc-impacted soil figures were not prepared.

Other Metals

“Other metals” are a secondary group comprising metals detected more often than not in the soil samples. However, the spatial extents of these detected metals are not as great or the metal is not as potentially harmful as the metals individually discussed above (arsenic, cadmium, lead, mercury, and zinc). “Other metals” does not include the metals individually discussed above or the nutrient metals that do not have exceedance criteria (calcium, magnesium, potassium, and sodium). The secondary group of metals includes aluminum, antimony, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, thallium, and vanadium. Iron results are discussed only when results exceeded the IRSL.

Twenty-eight surface soil and twenty-eight subsurface soil samples collected from Investigation Area 1 were analyzed by the CLP laboratory for other metals, and two XRF-screened surface soil samples were submitted to the laboratory for other metals analysis (Figures 4.2.2-7a and 4.2.2-7b). Tables 4.2.2-1a and 4.2.2-1b summarize the detected other metals results for Investigation Area 1 and list the RRLs and IRSLs for each of the other metals. Investigation Area 1 soil sample results exceeded the RRL or IRSL for the following compounds: cobalt, manganese, and thallium. RSLs and results for each metal are summarized below. Please note, the December 2009 RSLs were used for all metals except total chromium and thallium. Total chromium and thallium soil results were compared to the April 2009 RSLs.

Cobalt

The RRL and IRSL for cobalt are 23 and 300 mg/kg, respectively. The BTVs for cobalt in surface and subsurface soils are 12.9 and 13.8 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- Six surface soil sample results (20 percent) exceeded the RRL. No surface soil sample results exceeded the IRSL.
- Two subsurface soil sample results (7 percent) exceeded the RRL. No subsurface soil sample results exceeded the IRSL.
- The maximum detected surface soil cobalt concentration was 33.2 mg/kg in sample SB018A composed of sinter and slag materials.
- The maximum detected subsurface soil cobalt concentration was 72.7 mg/kg in sample SB012B collected from 8 to 10 ft bgs composed of native clay material.

Soil boring SB018 is located just east of the southeastern corner of Building 100, and soil boring SB012 is located right along the western boundary fence line of Investigation Area 1.

Manganese

The RRS� and IRS� for manganese are 1,800 and 23,000 mg/kg, respectively. The BTVs for manganese in surface and subsurface soils are 1,527 and 2,726 mg/kg, respectively. The surface BTV is below the RSLs and the subsurface BTV was above the RRS� but below the IRS�.

- Six surface soil sample results (20 percent) and one surface soil sample result (3 percent) exceeded the RRS� and IRS�, respectively.
- Two subsurface soil sample results (7 percent) exceeded the RRS�. No subsurface soil sample results exceeded the IRS�.
- The maximum detected surface soil manganese concentration was 28,400 mg/kg in sample SB018A composed of sinter and slag materials.
- The maximum detected subsurface soil manganese concentration was 5,220 mg/kg in sample SB500B-08 (a duplicate sample of SB406B-08) collected from 26 to 28 ft bgs composed of native clay material.

Soil borings SB018 and SB406 are located east of Building 100.

Thallium

The April 2009 RRS� and IRS� for thallium are 5.1 and 66 mg/kg, respectively. Surface and subsurface BTVs were not developed for thallium (Appendix RA-2).

- One surface soil sample result (3 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- No subsurface soil sample results exceeded the RRS� or IRS�.
- The maximum detected surface soil thallium concentration was 13.9 mg/kg in sample SB018A composed of sinter and slag materials.
- The maximum detected subsurface soil thallium concentration was 4.1 mg/kg in sample SB410B-08 collected from 18 to 20 ft bgs composed of sinter and slag materials.

Soil boring SB018A is located just east of the southeastern corner of Building 100, and soil boring SB410 is located in the southeastern corner of Investigation Area 1.

Within Investigation Area 1, a total of 58 soil samples were analyzed for “other metals,” of which 24 percent exceeded at least one RSL. The “other metals” exceedances were located on the eastern side of Building 100 and to the northeast, with most RSL exceedances occurring in surface soil. The “other metals” surface soils have been defined to the OU2 boundary. Impacted surface soils from Investigation Area 1 are shown in Figure 4.2.2-7c. The “other metals” subsurface soils have also been adequately defined to the OU2 boundary. Figure 4.2.2-7d shows the subsurface extents of other metals-impacted soil, for which there are no subsurface soil results that exceeded the IRSLs for “other metals” within Investigation Area 1.

Cyanide

Twenty-eight surface soil and all twenty-eight subsurface soil samples collected from Investigation Area 1 were analyzed by the CLP laboratory for cyanide, and two XRF-screened surface soil samples were submitted to the laboratory for cyanide analysis (Figures 4.2.2-7a and 4.2.2-7b). Tables 4.2.2-1a and 4.2.2-1b summarize the detected cyanide results for Investigation Area 1. The RRSL and IRSL for cyanide are 1,600 and 20,000 mg/kg, respectively. Surface and subsurface BTVs were not developed for cyanide (Appendix RA-2).

- No surface soil sample results (0 percent) exceeded the RRSL or IRSL.
- No subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected surface soil cyanide concentration was 4.2 mg/kg in sample SB410-08, composed of slag, sinter, and fill materials.

The maximum detected subsurface soil cyanide concentration was 22.9 mg/kg in sample SB003 collected from 8 to 10 ft bgs and composed of glacial till.

VOCs

Of the 40 surface soil samples collected from Investigation Area 1, 18 were analyzed by the CLP laboratory for VOCs (Figure 4.2.2-8a). Of the 28 subsurface soil samples collected from Investigation Area 1, 18 were analyzed by the CLP laboratory for VOCs (Figure 4.2.2-8b). Table 4.2.2-2 summarizes the detected VOC results for all the soil samples and the respective RRSL and IRSL for each VOC. Table S-11 in Appendix S-11 includes the complete VOC results for all the soil samples.

- No surface or subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.

SVOCs

Of the 40 surface soil samples collected from Investigation Area 1, 18 were analyzed by the CLP laboratory for SVOCs (Figure 4.2.2-9a). Of the 28 subsurface soil samples collected from Investigation Area 1, 18 were analyzed by the CLP laboratory for SVOCs (Figure 4.2.2-9b). Table 4.2.2-3 summarizes the detected SVOC results for all surface and subsurface soil samples. Table S-12 in Appendix S-12 includes the complete SVOC results for all soil samples. Most SVOCs were detected in at least one soil sample. Investigation Area 1 soil sample results exceeded the RRS� or IRS� for the following compounds and are discussed below: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

Benzo(a)anthracene

The RRS� and IRS� for benzo(a)anthracene are 150 and 2,100 µg/kg, respectively.

- Eight surface soil sample results (44 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- Two subsurface soil sample results (11 percent) exceeded the RRS�. No subsurface soil sample results exceeded the IRS�.
- The maximum detected surface soil benzo(a)anthracene concentration was 530 µg/kg in sample SB014A composed of sinter and slag materials.
- The maximum detected subsurface soil benzo(a)anthracene concentration was 750 µg/kg in sample SB019B collected from 5 to 7 ft bgs composed of sinter and slag materials.

Soil boring SB014 is located southeast of Building 100, and soil boring SB019 is located just east of the southeastern corner of Building 100.

Benzo(a)pyrene

The RRS� and IRS� for benzo(a)pyrene are 15 and 210 µg/kg, respectively.

- Thirteen surface soil sample results (87 percent) and six surface soil sample results (33 percent) exceeded the RRS� and IRS�, respectively.
- Six subsurface soil sample results (33 percent) and two subsurface soil sample results (11 percent) exceeded the RRS� and IRS�, respectively.

- The maximum detected surface soil benzo(a)pyrene concentration was 720 µg/kg in sample SB014A composed of sinter and slag materials.
- The maximum detected subsurface soil benzo(a)pyrene concentration was 850 µg/kg in sample SB019B collected from 5 to 7 ft bgs composed of sinter and slag materials.

Soil boring SB014 is located southeast of Building 100, and soil boring SB019 is located just east of the southeastern corner of Building 100.

Benzo(b)fluoranthene

The RRS� and IRS� for benzo(b)fluoranthene are 150 and 2,100 µg/kg, respectively.

- Eight surface soil sample results (44 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- Three subsurface soil sample results (17 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- The maximum detected surface soil benzo(b)fluoranthene concentration was 1,100 µg/kg in sample SB018A composed of sinter and slag materials.
- The maximum detected subsurface soil benzo(b)fluoranthene concentration was 1,600 µg/kg in sample SB019B collected from 5 to 7 ft bgs composed of sinter and slag materials.

Soil boring SB018 is located southeast of Building 100, and soil boring SB019 is located just east of the southeastern corner of Building 100.

Benzo(g,h,i)perylene

The RRS� and IRS� for benzo(g,h,i)perylene are 150 and 2,100 µg/kg, respectively.

- Seven surface soil sample results (39 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- Three subsurface soil sample results (17 percent) exceeded the RRS�. No subsurface soil sample results exceeded the IRS�.
- The maximum detected surface soil benzo(g,h,i)perylene concentration was 530 µg/kg in sample SB018A composed of sinter and slag materials.
- The maximum detected subsurface soil benzo(g,h,i)perylene concentration was 750 µg/kg in sample SB019B collected from 5 to 7 ft bgs composed of sinter and slag materials.

Soil boring SB018 is located southeast of Building 100, and soil boring SB019 is located just east of the southeastern corner of Building 100.

Dibenzo(a,h)anthracene

The RRSL and IRSL for dibenzo(a,h)anthracene are 15 and 210 µg/kg, respectively.

- Five surface soil sample results (28 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- One subsurface soil sample result (6 percent) exceeded the RRSL. No subsurface soil sample results exceeded the IRSL.
- The maximum detected surface soil dibenzo(a,h)anthracene concentration was 180 µg/kg in sample SB018A composed of sinter and slag materials.
- The maximum detected subsurface soil dibenzo(a,h)anthracene concentration was 290 µg/kg in sample SB019B collected from 5 to 7 ft bgs composed of sinter and slag materials.

Soil boring SB018 is located southeast of Building 100, and soil boring SB019 is located just east of the southeastern corner of Building 100.

Indeno(1,2,3-cd)pyrene

The RRSL and IRSL for indeno(1,2,3-cd)pyrene are 150 and 2,100 µg/kg, respectively.

- Eight surface soil sample results (44 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- Two subsurface soil sample results (11 percent) exceeded the RRSL. No subsurface soil sample results exceeded the IRSL.
- The maximum detected surface soil indeno(1,2,3-cd)pyrene concentration was 690 µg/kg in sample SB018A composed of sinter and slag materials.
- The maximum detected subsurface soil indeno(1,2,3-cd)pyrene concentration was 810 µg/kg in sample SB019B collected from 5 to 7 ft bgs composed of sinter and slag materials.

Soil boring SB018 is located southeast of Building 100, and soil boring SB019 is located just east of the southeastern corner of Building 100.

Within Investigation Area 1, a total of 36 soil samples were analyzed for SVOCs, of which 58 percent exceeded at least one RSL. Most SVOC exceedances were detected in samples of sinter and slag materials. Generally, SVOC concentrations were higher in surface soil than in subsurface soil, and the highest concentrations for both surface and subsurface soils were located just east of Building 100 at soil borings SB014, SB018, and SB019, largely sinter and slag fill materials. SVOCs in surface and subsurface soils have been fully defined in the vicinity of Building 100, particularly for the highest impacted soils as shown in Figures 4.2.2-9c and 4.2.2-9d.

PCBs

Of the 40 surface soil samples collected from Investigation Area 1, 28 were analyzed by the CLP laboratory for PCBs (Figure 4.2.2-10a). All 28 subsurface soil samples collected from Investigation Area 1 were analyzed by the CLP laboratory for PCBs (Figure 4.2.2-10b). Table 4.2.2-4a summarizes the detected PCB results for all the soil samples. Table S-13 in Appendix S-13 presents the full set of soil PCB results. Results for the following two PCB compounds exceeded the RRS� and IRS� and are discussed below: Aroclor-1254 and Aroclor-1260.

Aroclor-1254

The RRS� and IRS� for Aroclor-1254 are 220 and 740 µg/kg, respectively.

- One surface soil sample result (4 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- No subsurface soil sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected surface soil Aroclor-1254 concentration was 590 µg/kg in sample SB004A composed of a mixture of native soil, slag, and sinter.
- Aroclor-1254 was not detected in any of the Investigation Area 1 subsurface soil samples.

Aroclor-1260

The RRS� and IRS� for Aroclor-1260 are 220 and 740 µg/kg, respectively.

- Six surface soil sample results (21 percent) exceeded both the RRS� and IRS�.
- Six subsurface soil sample results (21 percent) exceeded both the RRS� and IRS�.
- The maximum detected surface soil Aroclor-1260 concentration was 210,000 µg/kg in sample SB250A (a duplicate sample of SB003A) composed of slag, sinter, and fill materials.

- The maximum detected subsurface soil Aroclor-1260 concentration was 39,000 µg/kg in sample SB291B (a duplicate sample of SB007B) collected from 8 to 10 ft bgs composed of native silty clay.

In addition to the samples submitted to the CLP laboratory, field test kits were used to analyze subsurface soil samples for PCBs to investigate the vertical extent of PCB contamination around Building 100. Field test kits were used on samples from eight soil borings (SB401 through SB406, SB408, and SB409) around Building 100 during the Phase II soil sampling event. SulTRAC used the L2000DX Analyzer by Dexsil Corporation to analyze the soil samples. The L2000DX Analyzer measures the total organic chloride content of a sample and then converts the chloride content to an equivalent concentration (Dexsil Corporation 2006). The margin of error for the L2000DX Analyzer is ± 10 percent. Organic chloride in soil can be associated with compounds other than PCBs. However, the L2000DX analyzer does not distinguish between organic chloride for different types of compounds (Dexsil Corporation 2006). Therefore, the total chloride results provide a very conservative value for the PCB test kit results as a worst-case scenario. At the time of sample collection, Dexsil Corporation recommended the use of Aroclor-1242 results to provide the most conservative results. However, the main Aroclor present around Building 100 was Aroclor-1260. Therefore, as a worst-case scenario, SulTRAC converted the total organic chloride content to Aroclor-1260 results using the equation described in the manual for the L2000DX Analyzer (Dexsil Corporation 2006) (Table 4.2.2-4b).

Table 4.2.2-4b presents the total chloride results, Aroclor-1242 PCB test kit results, converted Aroclor-1260 results, and the CLP laboratory analytical results for the eight soil boring locations. The shallowest 2-ft interval sample below 10 ft bgs that yielded a test kit PCB concentration less than 5 ppm was submitted to the CLP laboratory for confirmatory analysis. One exception was at soil boring location SB409, where the GeoProbe® reached refusal at 21 ft bgs. Therefore, the 20- to 21-ft-bgs interval sample was submitted to the CLP laboratory for analysis even though the test kit PCB result exceeded 5 ppm. The CLP Aroclor-1260 result for the subsurface soil sample from at SB409 exceeded the RRS� and IRS�. However, deeper samples collected from around SB409 did not contain Aroclor-1260 at concentrations exceeding the RSLs. Because the L2000DX Analyzer provides results for *total* organic chloride in the samples, it provides very conservative PCB results and the test kit Aroclor-1260 concentrations are much higher than the CLP laboratory Aroclor-1260 results. The vertical extent of PCB impacts has been delineated to a conservative depth of 34 to 36 ft bgs at soil boring SB408. However, because of the conservative nature of the PCB test kit results, the PCB results for the shallower interval above the 34 to 36 ft bgs interval may be below the RSLs.

Within Investigation Area 1, a total of 56 soil samples were analyzed for PCBs, of which 27 percent exceeded at least one RSL. The PCB exceedances generally were located around and east-northeast of Building 100, with the highest concentrations in surface soil. Deeper soil samples were collected from 10 of the 28 soil borings to investigate the vertical extent of PCB contamination discovered during the Phase I investigation. The Aroclor-1260 result for one subsurface soil sample, SB409B, collected from 20 to 21 ft bgs and composed of native red silty gravel and sand, exceeded both the RRL and IRL. Results for all other subsurface soil samples collected during the Phase II investigation from depths ranging from 10 to 36 ft bgs were below detection limit. PCBs may need further delineation of surface and subsurface soils to the west of SB007 and SB017 for future remedial design options; however, for the purposes of the RI, PCBs have been delineated both vertically and horizontally in Investigation Area 1. Figures 4.2.2-10c and 4.2.2-10d show the surface and subsurface extents of PCB-impacted soil, respectively.

Pesticides

Of the 40 surface soil samples collected from Investigation Area 1, 18 were analyzed by the CLP laboratory for pesticides (Figure 4.2.2-11a). Of the 28 subsurface soil samples collected from Investigation Area 1, 18 were analyzed by the CLP laboratory for pesticides (Figure 4.2.2-11b). Table 4.2.2-5 summarizes the detected pesticide results for all the soil samples. Table S-14 in Appendix S-14 presents the full set of soil pesticide results.

- No surface or subsurface soil sample results (0 percent) exceeded the RRL or IRL.

Asbestos

Of the 40 surface soil samples collected from Investigation Area 1, 18 were analyzed by STAT Laboratories for asbestos (Figure 4.2.2-12). Of the 28 subsurface soil samples collected from Investigation Area 1, 12 were analyzed by STAT Laboratories for asbestos (Figure 4.2.2-12). Table 4.2.2-6 summarizes the asbestos results for all the soil samples. Table S-15 in Appendix S-15 presents the full set of soil asbestos results.

- Four surface soil sample results (22 percent) were detected above the 0.25 percent detection limit.
- No subsurface soil sample results (0 percent) were detected above the 0.25 percent detection limit.
- The maximum percentage of asbestos detected in a surface soil sample was 2.5 percent in sample SB003A composed of slag, sinter, and fill materials.

Within Investigation Area 1, a total of 30 soil samples were analyzed for asbestos, of which 13 percent contained asbestos fibers of 0.25 percent or more. Asbestos in soil mostly is present within fill materials at the surface. Asbestos that was detected in surface soils have been adequately defined.

TCLP Metals

No soil samples collected from Investigation Area 1 were analyzed for TCLP metals.

SPLP Metals

No soil samples collected from Investigation Area 1 were analyzed for SPLP metals.

Investigation Area 1 Summary

Soil sample results for Investigation Area 1 reveal that the following metals were detected at concentrations exceeding either the RRLs or IRSs: arsenic, cadmium, lead, zinc, cobalt, manganese, and thallium. Soil sample results for Investigation Area 1 reveal that the following organic compounds were detected at concentrations exceeding the RSLs: SVOCs (a total of six compounds) and PCBs (a total of two compounds). Asbestos also was detected in surface soil at Investigation Area 1. The areas of highest soil impacts (analytes that exceeded the IRSs) at Investigation Area 1 are summarized below.

The main area of arsenic-impacted surface soil extends into Investigation Area 1 (Figure 4.2.2-2c) and focused mainly around Building 100. The highest surface soil arsenic concentration was detected in a sample collected from the southeastern corner of Investigation Area 1. The arsenic-impacted subsurface soils are a smaller area than the surface soils and is located in the southeastern portion of Investigation Area 1 (Figure 4.2.2-2d). A smaller arsenic-impacted subsurface soil area is located in the southwestern portion of Investigation Area 1. The main area of lead-impacted surface soil extends into Investigation Area 1 (Figure 4.2.2-4c). The highest surface soil lead concentration was detected in a sample collected from the northeastern corner of Building 100. Two smaller areas of lead-impacted subsurface soil exist at Investigation Area 1: one area that encompasses Building 100 and another smaller area in the east-central portion of Investigation Area 1 (Figure 4.2.2-4d). The highest surface soil SVOC concentrations were detected in samples collected from along the eastern portion of Building 100 (Figure 4.2.2-9c). A smaller SVOC-impacted subsurface soil area exists just east of Building 100 (Figure 4.2.2-9d). The area of PCB-impacted surface soil is localized just east of Building 100 (Figure 4.2.2-10c). Two smaller areas of PCB-impacted subsurface soil exist along the southern portion of Building 100 and off the northeast corner of Building 100 (Figure 4.2.2-10d).

4.2.2.2 Investigation Area 2: Rolling Mill

A total of 82 soil samples were collected from Investigation Area 2, Rolling Mill (Figure 4.2.2-1a). Of the 82 soil samples, there were 44 total surface soil samples, 36 surface soil boring and 8 surface grab samples, and 38 were subsurface soil boring samples. The surface and subsurface soil total metals and cyanide, VOC, SVOC, PCB, pesticides, asbestos, TCLP metals, and SPLP metals results for Investigation Area 2 are summarized below, followed by a summary of the Investigation Area 2 results.

Metals and Cyanide

Of the 44 (36 soil boring and 8 grab) surface soil samples collected from Investigation Area 2, 36 soil boring samples were analyzed for total metals and cyanide. Eight surface soil samples from Investigation Area 2 were screened using the XRF analyzer for arsenic, cadmium, lead, and zinc. None of the surface soil samples screened using the XRF analyzer were submitted to the CLP laboratory for analysis. All 38 subsurface soil boring samples from Investigation Area 2 were analyzed for total metals and cyanide. Tables 4.2.2-1a and 4.2.2-1b summarize the detected metals and cyanide results for the soil boring and XRF-screened samples, respectively. Table S-10 in Appendix S-10 presents the full set of metals and cyanide results for the soil boring samples. Analytical results are discussed for six individual analytes groups: arsenic, cadmium, lead, mercury, zinc, and cyanide. In addition, analytical results for other analytes detected also are discussed under a general category called “other metals.” Because of the large number of analytical detections and concentrations exceeding the US EPA RREL and IREL, results for the individual metal analytes are discussed below based on the number of RSL exceedances.

Arsenic

All 44 surface soil and all 38 subsurface soil samples collected from Investigation Area 2 were analyzed by the CLP laboratory or screened using the XRF analyzer for arsenic (Figures 4.2.2-2a and 4.2.2-2b). The RREL and IREL for arsenic are 0.39 and 1.6 mg/kg, respectively. The BTVs for arsenic in surface and subsurface soils are 10.7 and 12.44 mg/kg, respectively. Both BTVs were above both the RREL and IREL.

- Thirty-seven surface soil sample results (84 percent) and thirty-six surface soil sample results (82 percent) exceeded the RREL and IREL, respectively. Twenty-three surface soil sample results (52 percent) exceeded the BTV.

- All 38 subsurface soil sample results (100 percent) exceeded the RRS�, and 36 subsurface soil sample results (95 percent) exceeded the IRS�. Thirteen subsurface soil sample results (34 percent) exceeded the BTV.
- The maximum detected surface soil arsenic concentration was 66 mg/kg in sample SB419A-08 composed of slag, sinter, and fill materials.
- The maximum detected subsurface soil arsenic concentration was 93.7 mg/kg in sample SB178B collected from 8 to 10 ft bgs composed of fill materials.

Within Investigation Area 2, a total of 82 soil samples were analyzed or screened for arsenic, of which 91 percent exceeded at least one RSL. Arsenic in soil exceeded the BTV in 44 percent of the total samples in Investigation Area 2. Arsenic surface soil BTV and RSL exceedances were primarily to the north, east, and west of the Rolling Mill in Investigation Area 2. Arsenic in surface soils has been adequately defined. Arsenic subsurface soil BTV and RSL exceedances were mainly north of the Rolling Mill with two smaller impacted areas in the western portion Investigation Area 2. The subsurface soils have been adequately defined within Investigation Area 2 to the OU2 boundary. The delineated horizontal and vertical extents of arsenic-impacted soils are shown in Figures 4.2.2-2c and 4.2.2-2d.

Cadmium

All 44 surface soil and all 38 subsurface soil samples collected from Investigation Area 2 were analyzed by the CLP laboratory or screened using the XRF analyzer for cadmium (Figures 4.2.2-3a and 4.2.2-3b). The RRS� and IRS� for cadmium are 70 and 800 mg/kg, respectively. The BTVs for cadmium in surface and subsurface soils are 7.1 and 4.68 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- Twelve surface soil sample results (27 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- Four subsurface soil sample results (11 percent) exceeded the RRS�. No subsurface soil sample results exceeded the IRS�.
- The maximum detected surface soil cadmium concentration was 197 mg/kg in sample SB129A composed of fill materials.
- The maximum detected subsurface soil cadmium concentration was 133 mg/kg in sample SB282B (a duplicate sample of SB130B) collected from 8 to 10 ft bgs composed of fill materials.

Within Investigation Area 2, a total of 82 soil samples were analyzed or screened for cadmium, of which 20 percent exceeded at least one RSL. The highest concentrations of cadmium were in the fill materials. The highest density of cadmium exceedances (RRSLs) was located north of the Rolling Mill building. Cadmium in surface and subsurface soils has been horizontally and vertically defined to the OU2 boundary within Investigation Area 2. No surface or subsurface soils exceeded the IRSLs for cadmium within Investigation Area 2.

Lead

All 44 surface soil and all 38 subsurface soil samples collected from Investigation Area 2 were analyzed by the CLP laboratory or screened using the XRF analyzer for lead (Figures 4.2.2-4a and 4.2.2-4b). The RRSL and IRSL for lead are 400 and 800 mg/kg, respectively. The BTVs for lead in surface and subsurface soils are 103 and 66.1 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- Twenty-four surface soil sample results (55 percent) and fourteen surface soil sample results (32 percent) exceeded the RRSL and IRSL, respectively.
- Eleven subsurface soil sample results (29 percent) and ten subsurface soil sample results (26 percent) exceeded the RRSL and IRSL, respectively.
- The maximum detected surface soil lead concentration was 9,410 mg/kg in sample SB179A composed of fill materials.
- The maximum detected subsurface soil lead concentration was 10,700 mg/kg in sample SB440B-08 collected from 8 to 10 ft bgs composed of slag and fill materials.

Within Investigation Area 2, a total of 82 soil samples were analyzed or screened for lead, of which 43 percent exceeded at least one RSL. The highest lead concentrations were detected in fill materials in both surface and subsurface samples and concentrated north of the Rolling Mill building around an AST (labeled Cyanide). All the subsurface soil samples whose results exceeded the RSLs were composed of slag, sinter, and fill materials collected from 4 to 6, 8 to 10, or 10 to 12 ft bgs. Lead in surface soils has been adequately delineated to the OU2 boundary and in subsurface soils has been horizontally delineated within Investigation Area 2. Figures 4.2.2-4c and 4.2.2-4d show the surface and subsurface extents of lead-impacted soil, respectively.

Mercury

A total of 36 soil and all 38 subsurface soil samples collected from Investigation Area 2 were analyzed by the CLP laboratory for mercury (Figures 4.2.2-5a and 4.2.2-5b). The RRSL and IRSL for mercury are 5.6 and 34 mg/kg, respectively. The BTVs for mercury in surface and subsurface soils are 1.32 and 1.33 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- No surface soil sample results (0 percent) exceeded the RRSL or IRSL.
- No subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected surface soil mercury concentration was 0.95 mg/kg in sample SB129A composed of fill materials.
- The maximum detected subsurface soil lead concentration was 0.89 mg/kg in sample SB201B collected from 6 to 8 ft bgs composed of silty clay.

Zinc

All 44 surface soil and all 38 subsurface soil samples collected from Investigation Area 2 were analyzed by the CLP laboratory or screened using the XRF analyzer for zinc (Figures 4.2.2-6a and 4.2.2-6b). The RRSL and IRSL for zinc are 23,000 and 310,000 mg/kg, respectively. The BTVs for zinc in surface and subsurface soils are 1,310 and 740 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- Nineteen surface soil sample results (43 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- Ten subsurface soil sample results (26 percent) exceeded the RRSL. No subsurface soil sample results exceeded the IRSL.
- The maximum detected surface soil zinc concentration was 129,000 mg/kg in sample SB134A composed of native silty sandy materials.
- The maximum detected subsurface soil zinc concentration was 68,700 mg/kg in sample SB164B collected from 8 to 10 ft bgs composed of fill materials.

Within Investigation Area 2, a total of 82 soil samples were analyzed or screened for zinc, of which 35 percent exceeded the RRSL. The surface soil samples exceeding the RRSL were composed of both native and fill materials. However, the subsurface soil samples exceeding the RRSL were composed of fill materials only. The highest concentrations of zinc both in surface and subsurface soil were detected

north of the Rolling Mill building around the AST similar to the lead RSL exceedances. Zinc in surface soils has been adequately delineated to the OU2 boundary and subsurface soils have been horizontally delineated within Investigation Area 2. No surface or subsurface soils exceeded the IRSLS for zinc within the OU2 boundary. Therefore, surface and subsurface zinc-impacted soil figures were not prepared.

Other Metals

“Other metals” are a secondary group comprising metals detected more often than not in the soil samples. However, the spatial extents of these detected metals are not as great or the metal is not as potentially harmful as the metals individually discussed above (arsenic, cadmium, lead, mercury, and zinc). “Other metals” does not include the metals individually discussed above or the nutrient metals that do not have exceedance criteria (calcium, magnesium, potassium, and sodium). The secondary group of metals includes aluminum, antimony, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, thallium, and vanadium. Iron results are discussed only when results exceeded the IRSLS.

A total of 36 surface soil and 38 subsurface soil samples collected from Investigation Area 2 were analyzed by the CLP laboratory for other metals (Figures 4.2.2-7a and 4.2.2-7b). Table 4.2.2-1a summarize the detected other metals results for Investigation Area 2 and list the RRSLS and IRSLS for each of the other metals. Investigation Area 2 soil sample results exceeded the RRSLS or IRSLS for the following compounds: cobalt and manganese. RSLs and results for each metal are summarized below. Please note, the December 2009 RSLs were used for all metals except total chromium and thallium. Chromium and thallium results were compared to the April 2009 RSLs.

Cobalt

The RRSLS and IRSLS for cobalt are 23 and 300 mg/kg, respectively. The BTVs for cobalt in surface and subsurface soils are 12.9 and 13.8 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- Five surface soil sample results (14 percent) exceeded the RRSLS. No surface soil sample results exceeded the IRSLS.
- Three subsurface soil sample results (8 percent) exceeded the RRSLS. No subsurface soil sample results exceeded the IRSLS.
- The maximum detected surface soil cobalt concentration was 31.1 mg/kg in sample SB420A-08 composed of slag, sinter, and fill materials.

- The maximum detected subsurface soil cobalt concentration was 31.4 mg/kg in sample SB164B collected from 8 to 10 ft bgs composed of fill materials.

Soil boring SB420 is located in the northeast corner of Investigation Area 2, and soil boring SB164 is located at the southwestern corner of the AST north of the Rolling Mill building.

Manganese

The RRSL and IRSL for manganese are 1,800 and 23,000 mg/kg, respectively. The BTVs for manganese in surface and subsurface soils are 1,527 and 2,726 mg/kg, respectively. The surface BTV is below the RSLs and the subsurface BTV was above the RRSL but below the IRSL.

- Two surface soil sample results (6 percent) exceeded the RRSL and surface soil BTV. No surface soil sample results exceeded the IRSL.
- Three subsurface soil sample results (8 percent) exceeded the RRSL. Of the three subsurface soil samples that exceeded the RRSL, one was below the subsurface soil BTV. No subsurface soil sample results exceeded the IRSL.
- The maximum detected surface soil manganese concentration was 5,190 mg/kg in sample SB318A (a duplicate sample of SB142A) composed of native materials.
- The maximum detected subsurface soil manganese concentration was 3,700 mg/kg in sample SB143B collected from 8 to 10 ft bgs composed of native materials.

Soil boring SB142 is located east of the Rolling Mill building, and soil boring SB143 is located north of SB142.

Within Investigation Area 2, a total of 74 soil samples were analyzed for “other metals,” of which 18 percent exceeded at least one RSL. The “other metals” exceedances were sporadic and not localized in a particular area within Investigation Area 2. There were few “other metals” exceedances scattered within Investigation Area 2. “Other metals” have been horizontally and vertically defined within Investigation Area 2. No surface or subsurface soil results exceeded the IRSLs for “other metals” within Investigation Area 2.

Cyanide

A total of 36 surface soil and all 38 subsurface soil samples collected from Investigation Area 2 were analyzed for cyanide (Figures 4.2.2-7a and 4.2.2-7b). Table 4.2.2-1a summarizes the detected cyanide

results for Investigation Area 2. The RRSL and IRSL for cyanide are 1,600 and 20,000 mg/kg, respectively. Surface and subsurface BTVs were not developed for cyanide (Appendix RA-2).

- One surface soil sample result (3 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- No subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected surface soil cyanide concentration was 2,840 mg/kg in sample SB438A-08 composed of native and fill materials.
- The maximum detected subsurface soil cyanide concentration was 1,230 mg/kg in sample SB438B-08 collected from 6 to 8 ft bgs composed of silty clay.

Within Investigation Area 2, the cyanide result exceeded the RRSL in one sample, SB438A, collected from within the southwestern portion of the Rolling Mill building. No other sample results exceeded the RSLs. The nature and extent of cyanide-impacted soil has been adequately defined both horizontally and vertically in Investigation Area 2. No surface or subsurface soil results exceeded the IRSLs for cyanide within OU2 and therefore, impact figures were not prepared for cyanide.

VOCs

Of the 44 surface soil samples collected from Investigation Area 2, 37 were analyzed by the CLP laboratory for VOCs (Figure 4.2.2-8a). All 38 subsurface soil samples collected from Investigation Area 2 were analyzed by the CLP laboratory for VOCs (Figure 4.2.2-8b). Table 4.2.2-2 summarizes the detected VOC results for all the soil samples and the respective RRSL and IRSL for each VOC. Table S-11 in Appendix S-11 includes the complete VOC results for all the soil samples. Investigation Area 2 soil sample results exceeded the RRSLs or IRSLs for the following VOCs: PCE and TCE. RSLs and results for each VOC are summarized below.

Tetrachloroethene

The RRSL and IRSL for PCE are 550 and 2,600 µg/kg, respectively.

- No surface soil sample results (0 percent) exceeded the RRSL or IRSL.
- One subsurface soil sample result (3 percent) exceeded the RRSL. No subsurface soil sample results exceeded the IRSL.
- The maximum detected surface soil PCE concentration was 63 µg/kg in sample SB140A composed of native soil and silty clay, slag, and sinter materials.

- The maximum detected subsurface soil PCE concentration was 1,000 µg/kg in sample SB134B collected from 4 to 6 ft bgs composed of sinter and slag materials.

Soil boring SB134B is located at the northwest corner of the Rolling Mill building.

Trichloroethene

The RRS� and IRS� for TCE are 2,800 and 14,000 µg/kg, respectively.

- No surface soil sample results (0 percent) exceeded the RRS� or IRS�.
- One subsurface soil sample result (3 percent) exceeded both the RRS� and IRS�.
- The maximum detected surface soil TCE concentration was 210 µg/kg in sample SB269A (a duplicate sample of SB134A) composed of silty sand.
- The maximum detected subsurface soil TCE concentration was 120,000 µg/kg in sample SB134B collected from 4 to 6 ft bgs composed of sinter and slag materials.

Soil boring SB134B is located at the northwest corner of the Rolling Mill building.

Within Investigation Area 2, a total of 75 soil samples were analyzed for VOCs, of which 1 percent exceeded at least one RSL. The subsurface soil results for only one boring location, SB134, exceeded the RSLs for the two VOCs detected. Therefore, VOC-impacted soil appears to be localized in the subsurface near soil boring SB134. Figure 4.2.2-8c shows the subsurface extent of VOC-impacted soil. No surface soils exceeded the IRS�s for VOCs within the OU2 boundary; therefore, a surface VOC-impacted soil figure was not prepared.

SVOCs

Of the 44 surface soil samples collected from Investigation Area 2, 29 were analyzed by the CLP laboratory for SVOCs (Figure 4.2.2-9a). Of the 38 subsurface soil samples collected from Investigation Area 2, 30 were analyzed by the CLP laboratory for SVOCs (Figure 4.2.2-9b). Table 4.2.2-3 summarizes the detected SVOC results for all surface and subsurface soil samples. Table S-12 in Appendix S-12 includes the complete SVOC results for all soil samples. Most SVOCs were detected in at least one soil sample. Investigation Area 2 soil sample results exceeded the RRS� or IRS� for the following compounds and are discussed below: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and naphthalene.

Benzo(a)anthracene

The RRS� and IRS� for benzo(a)anthracene are 150 and 2,100 µg/kg, respectively.

- Eleven surface soil sample results (38 percent) and two surface soil sample results (7 percent) exceeded the RRS� and IRS�, respectively.
- Four subsurface soil sample results (13 percent) exceeded the RRS�. No subsurface soil sample results exceeded the IRS�.
- The maximum detected surface soil benzo(a)anthracene concentration was 71,000 µg/kg in sample SB140A composed of native soil and silty clay, slag, and sinter materials.
- The maximum detected subsurface soil benzo(a)anthracene concentration was 820 µg/kg in sample SB439B-08 collected from 10 to 12 ft bgs composed of silty clay.

Soil boring SB140 is located along the outer westernmost wall of the Rolling Mill building, and soil boring SB439 is located inside the Rolling Mill building just southeast of SB140.

Benzo(a)pyrene

The RRS� and IRS� for benzo(a)pyrene are 15 and 210 µg/kg, respectively.

- Twenty surface soil sample results (69 percent) and nine surface soil sample results (31 percent) exceeded the RRS� and IRS�, respectively.
- Nine subsurface soil sample results (30 percent) and two subsurface soil sample results (7 percent) exceeded the RRS� and IRS�, respectively.
- The maximum detected surface soil benzo(a)pyrene concentration was 49,000 µg/kg in sample SB140A composed of native soil and silty clay, slag, and sinter materials.
- The maximum detected subsurface soil benzo(a)pyrene concentration was 510 µg/kg in sample SB439B-08 collected from 10 to 12 ft bgs composed of silty clay.

Soil boring SB140 is located along the outer westernmost wall of the Rolling Mill building, and soil boring SB439 is located inside the Rolling Mill building just southeast of SB140.

Benzo(b)fluoranthene

The RRS� and IRS� for benzo(b)fluoranthene are 150 and 2,100 µg/kg, respectively.

- Nine surface soil sample results (31 percent) and three surface soil sample results (10 percent) exceeded the RRS� and IRS�, respectively.
- Five subsurface soil sample results (17 percent) exceeded the RRS�. No subsurface soil sample results exceeded the IRS�.
- The maximum detected surface soil benzo(b)fluoranthene concentration was 72,000 µg/kg in sample SB140A composed of native soil and silty clay, slag, and sinter materials.
- The maximum detected subsurface soil benzo(b)fluoranthene concentration was 770 µg/kg in sample SB439B-08 collected from 10 to 12 ft bgs composed of silty clay.

Soil boring SB140 is located along the outer westernmost wall of the Rolling Mill building, and soil boring SB439 is located inside the Rolling Mill building just southeast of SB140.

Benzo(g,h,i)perylene

The RRS� and IRS� for benzo(g,h,i)perylene are 150 and 2,100 µg/kg, respectively.

- Seven surface soil sample results (24 percent) and two surface soil sample results (7 percent) exceeded the RRS� and IRS�, respectively.
- One subsurface soil sample result (3 percent) exceeded the RRS�. No subsurface soil sample results exceeded the IRS�.
- The maximum detected surface soil benzo(g,h,i)perylene concentration was 7,900 µg/kg in sample SB140A composed of native soil and silty clay, slag, and sinter materials.
- The maximum detected subsurface soil benzo(g,h,i)perylene concentration was 260 µg/kg in sample SB439B-08 collected from 10 to 12 ft bgs composed of silty clay.

Soil boring SB140 is located along the outer westernmost wall of the Rolling Mill building, and soil boring SB439 is located inside the Rolling Mill building just southeast of SB140.

Benzo(k)fluoranthene

The RRS� and IRS� for benzo(k)fluoranthene are 1,500 and 21,000 µg/kg, respectively.

- Two surface soil sample results (7 percent) and one surface soil sample results (3 percent) exceeded the RRS� and IRS�, respectively.
- No subsurface soil sample results (0 percent) exceeded the RRS� or IRS�.

- The maximum detected surface soil benzo(k)fluoranthene concentration was 25,000 µg/kg in sample SB140A composed of native soil and silty clay, slag, and sinter materials.
- The maximum detected subsurface soil benzo(k)fluoranthene concentration was 270 µg/kg in sample SB439B-08 collected from 10 to 12 ft bgs composed of silty clay.

Soil boring SB140 is located along the outer westernmost wall of the Rolling Mill building, and soil boring SB439 is located inside the Rolling Mill building just southeast of SB140.

Chrysene

The RRS� and IRS� for chrysene are 15,000 and 210,000 µg/kg, respectively.

- Two surface soil sample results (7 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- No subsurface soil sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected surface soil chrysene concentration was 62,000 µg/kg in sample SB140A composed of native soil and silty clay, slag, and sinter materials.
- The maximum detected subsurface soil chrysene concentration was 750 µg/kg in sample SB439B-08 collected from 10 to 12 ft bgs composed of silty clay.

Soil boring SB140 is located along the outer westernmost wall of the Rolling Mill building, and soil boring SB439 is located inside the Rolling Mill building just southeast of SB140.

Dibenzo(a,h)anthracene

The RRS� and IRS� for dibenzo(a,h)anthracene are 15 and 210 µg/kg, respectively.

- Ten surface soil sample results (34 percent) and three surface soil sample results (10 percent) exceeded the RRS� and IRS�, respectively.
- One subsurface soil sample result (3 percent) exceeded the RRS�. No subsurface soil sample results exceeded the IRS�.
- The maximum detected surface soil dibenzo(a,h)anthracene concentration was 7,300 µg/kg in sample SB140A composed of native soil and silty clay, slag, and sinter materials.
- The maximum detected subsurface soil dibenzo(a,h)anthracene concentration was 100 µg/kg in sample SB439B-08 collected from 10 to 12 ft bgs composed of silty clay.

Soil boring SB140 is located along the outer westernmost wall of the Rolling Mill building, and soil boring SB439 is located inside the Rolling Mill building just southeast of SB140.

Indeno(1,2,3-cd)pyrene

The RRS� and IRS� for indeno(1,2,3-cd)pyrene are 150 and 2,100 µg/kg, respectively.

- Nine surface soil sample results (31 percent) and two surface soil sample results (7 percent) exceeded the RRS� and IRS�, respectively.
- Two subsurface soil sample results (7 percent) exceeded the RRS�. No subsurface soil sample results exceeded the IRS�.
- The maximum detected surface soil indeno(1,2,3-cd)pyrene concentration was 25,000 µg/kg in sample SB140A composed of native soil and silty clay, slag, and sinter materials.
- The maximum detected subsurface soil indeno(1,2,3-cd)pyrene concentration was 360 µg/kg in sample SB439B-08 collected from 10 to 12 ft bgs composed of silty clay.

Soil boring SB140 is located along the outer westernmost wall of the Rolling Mill building, and soil boring SB439 is located inside the Rolling Mill building just southeast of SB140.

Naphthalene

The RRS� and IRS� for naphthalene are 3,600 and 18,000 µg/kg, respectively.

- One surface soil sample result (3 percent) exceeded both the RRS� and IRS�.
- No subsurface soil sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected surface soil naphthalene concentration was 21,000 µg/kg in sample SB140A composed of native soil and silty clay, slag, and sinter materials.
- The maximum detected subsurface soil naphthalene concentration was 120 µg/kg in sample SB140B collected from 8 to 10 ft bgs composed of silty clay.

Soil boring SB140 is located along the outer westernmost wall of the Rolling Mill building.

Within Investigation Area 2, a total of 59 soil samples were analyzed for SVOCs, of which 49 percent exceeded at least one RSL. Most SVOC exceedances were detected in samples containing sinter and slag materials. Generally, SVOC concentrations were higher in surface soil than in subsurface soil. SVOC-impacted surface soil is scattered throughout Investigation Area 2, with the highest concentrations inside

or near the Rolling Mill building. SVOC-impacted subsurface soil generally is located around and near the Rolling Mill building in Investigation Area 2. The highest concentrations of SVOCs were detected in surface and subsurface soil samples collected from SB140 and SB439. For the purposes of this RI, the surface and subsurface soils have been adequately delineated. Figures 4.2.2-9c and 4.2.2-9d show the surface and subsurface extents of SVOC-impacted soil, respectively.

PCBs

Of the 44 surface soil samples collected from Investigation Area 2, 29 were analyzed by the CLP laboratory for PCBs (Figure 4.2.2-10a). Of the 38 subsurface soil samples collected from Investigation Area 2, 30 were analyzed by the CLP laboratory for SVOCs (Figure 4.2.2-10b). Table 4.2.2-4a summarizes the detected PCB results for all the soil samples. Table S-13 in Appendix S-13 presents the full set of soil PCB results. Three of the nine PCB compounds analyzed for were detected in at least one soil sample. Results for the following two PCB compounds exceeded the RRS� and IRS� and are discussed below: Aroclor-1248 and Aroclor-1254.

Aroclor-1248

The RRS� and IRS� for Aroclor-1248 are 220 and 740 µg/kg, respectively.

- Four surface soil sample results (14 percent) and two surface soil sample results (7 percent) exceeded the RRS� and IRS�.
- One subsurface soil sample result (3 percent) exceeded both the RRS� and IRS�.
- The maximum detected surface soil Aroclor-1248 concentration was 16,000 µg/kg in sample SB134A composed of silty sand.
- The maximum detected subsurface soil Aroclor-1248 concentration was 2,100 µg/kg in sample SB134B collected from 4 to 6 ft bgs composed of sinter and slag materials.

Soil boring SB134 is located at the northwestern corner of the Rolling Mill building.

Aroclor-1254

The RRS� and IRS� for Aroclor-1254 are 220 and 740 µg/kg, respectively.

- Two surface soil sample results (7 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- No subsurface soil sample results (0 percent) exceeded the RRS� or IRS�.

- The maximum detected surface soil Aroclor-1254 concentration was 300 µg/kg in sample SB431A-08 composed of slag, sinter, and fill materials.
- Aroclor-1254 was not detected in any of the Investigation Area 2 subsurface soil samples.

Soil boring SB431 is located east of the Rolling Mill building on a concrete pad.

Within Investigation Area 2, a total of 59 soil samples were analyzed for PCBs, of which 10 percent exceeded at least one RSL. Of the 29 surface soil boring locations sampled for PCBs, 5 yielded samples exceeding at least one RSL for at least one PCB compound. These five soil borings generally are located around and north of the Rolling Mill building. Of the 29 surface soil boring locations, one location (SB134) had a corresponding subsurface soil sample result that exceeded the RRSL and IRSL. The subsurface soil sample was collected at 4 to 6 ft bgs. Other subsurface soil samples around SB134 were collected at deeper intervals and did not exceed and RSLs. The highest PCB concentrations were detected in surface soil. PCBs have been horizontally and vertically delineated in Investigation Area 2. Figures 4.2.2-10c and 4.2.2-10d show the surface and subsurface extents of PCB-impacted soil, respectively.

Pesticides

Of the 44 surface soil samples collected from Investigation Area 2, 29 were analyzed by the CLP laboratory for pesticides (Figure 4.2.2-11a). Of the 38 subsurface soil samples collected from Investigation Area 2, 30 were analyzed by the CLP laboratory for pesticides (Figure 4.2.2-11b). Table 4.2.2-5 summarizes the detected pesticide results for all the soil samples. Table S-14 in Appendix S-14 presents the full set of soil pesticide results. Results for the following pesticide exceeded the RRSL and are discussed below: heptachlor.

Heptachlor

The RRSL and IRSL for heptachlor are 110 and 380 µg/kg, respectively.

- One surface soil sample result (3 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- No subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected surface soil heptachlor concentration was 170 µg/kg in sample SB134A composed of silty sand.

- The maximum detected subsurface soil heptachlor concentration was 27 µg/kg in sample SB134B composed of sinter and slag materials.

Soil boring SB134 is located at the northwestern corner of the Rolling Mill building.

Within Investigation Area 2, a total of 59 soil samples were analyzed for pesticides, of which 3 percent exceeded the IRSL. Heptachlor was detected at a concentration exceeding the IRSL in a surface soil sample collected from soil boring SB134 at the northwestern corner of the Rolling Mill building. The nature and extent of pesticides-impacted soil has been adequately defined both horizontally and vertically in Investigation Area 2. No surface or subsurface soils exceeded the IRSLS for pesticides within the OU2 boundary. Therefore, surface and subsurface pesticide-impacted soil figures were not prepared.

Asbestos

Of the 44 surface soil samples collected from Investigation Area 2, 28 were analyzed by STAT Laboratories for asbestos (Figure 4.2.2-12). Of the 38 subsurface soil samples collected from Investigation Area 2, 5 were analyzed by STAT Laboratories for asbestos. Table 4.2.2-6 summarizes the asbestos results for all the soil samples. Table S-15 in Appendix S-15 presents the full set of soil asbestos results.

- One surface soil sample result (4 percent) was detected above the 0.25 percent detection limit.
- No subsurface soil sample results (0 percent) were detected above the 0.25 percent detection limit.
- The maximum detected percentage of asbestos in a surface soil sample was 3.75 percent in sample SB129A composed of fill materials.

Within Investigation Area 2, a total of 33 soil samples were analyzed for asbestos, of which only 3 percent contained asbestos fibers of 0.25 percent or more. The result for soil sample SB129A collected from northeast of the Rolling Mill building contained more than 0.25 percent asbestos fibers. The nature and extent of asbestos-impacted soil has been adequately defined both horizontally and vertically in Investigation Area 2.

TCLP Metals

No soil samples collected from Investigation Area 2 were analyzed for TCLP metals.

SPLP Metals

No soil samples collected from Investigation Area 2 were analyzed for SPLP metals.

Investigation Area 2 Summary

Soil sample results for Investigation Area 2 reveal that the following metals were detected at concentrations exceeding the RSLs: arsenic, cadmium, lead, mercury, zinc, cobalt, manganese, and cyanide. Surface and subsurface soil sample results for Investigation Area 2 reveal that the following organic compounds were detected at concentrations exceeding the RSLs: VOCs (a total of 2 compounds), SVOCs (a total of 9 compounds), PCBs (a total of 2 compounds), and pesticides (a total of 1 compound). Asbestos also was detected in one surface soil sample collected from Investigation Area 2. The areas of highest soil impacts (analytes that exceeded the IRSLS) at Investigation Area 2 are summarized below.

The main area of arsenic-impacted surface extends into the northeastern portion of Investigation Area 2 (Figure 4.2.2-2c). Some arsenic-impacted soil also exists along the western portion of the Rolling Mill building. Arsenic-impacted subsurface soils are located in the northeastern portion with two small areas along the western portion of Investigation Area 2 (Figure 4.2.2-2d). The area of arsenic-impacted subsurface soil is smaller than the surface soils. The main area of lead-impacted surface soil is located north-northeast of the Rolling Mill building, and another smaller area is located in the west-central portion of Investigation Area 2 (Figure 4.2.2-4c). The main area of lead-impacted subsurface soil primarily is located north of the Rolling Mill building in the northeastern portion of Investigation Area 2 (Figure 4.2.2-4d). The subsurface soil sample from one soil boring, SB134, contained VOCs at concentrations exceeding the IRSLS. This sample was collected from the northwest corner of the Rolling Mill building (Figure 4.2.2-8c). Investigation Area 2 contains two main areas of SVOC-impacted surface soil (Figure 4.2.2-9c). The larger area encompasses the northwestern portion of Investigation Area 2 and extends south into the western portion of the Rolling Mill building. A smaller area is located east of the Rolling Mill building. SVOC-impacted subsurface soil exists in the west-central portion of Investigation Area 2 (Figure 4.2.2-9d). An area of PCB-impacted surface and subsurface soil is located in the northwestern corner of the Rolling Mill building (Figures 4.2.2-10c and 4.2.2-10d).

The Rolling Mill building is currently in use and although the sampling was adequate to characterize the nature and extent of contamination in OU2 Investigation Area 2, including the Rolling Mill building, this characterization does not preclude any future occupational hazard inside the Rolling Mill.

4.2.2.3 Investigation Area 3: Former Main Industrial Area

A total of 375 soil samples were collected from Investigation Area 3, the former main industrial area (Figure 4.2.2-1a). Of the 377 soil samples, there were 230 total surface soil samples, 166 surface soil boring and 64 surface grab samples, and 145 were subsurface soil boring samples. The surface and subsurface soil metals and cyanide, VOC, SVOC, PCB, pesticides, asbestos, TCLP metals, and SPLP metals results for Investigation Area 3 are summarized below, followed by a summary of the Investigation Area 3 results.

Metals and Cyanide

Of the 230 (166 soil boring and 64 grab) surface soil samples collected from Investigation Area 3, all 166 surface soil boring samples were analyzed for total metals and cyanide. Sixty-four surface soil samples from Investigation Area 3 were screened using the XRF analyzer for arsenic, cadmium, lead, and zinc. Of the 64 XRF-screened surface soil grab samples, 22 were submitted to the CLP laboratory for total metals and cyanide analysis. All 145 subsurface soil boring samples collected from Investigation Area 3 were analyzed for total metals and cyanide. Tables 4.2.2-1a and 4.2.2-1b summarize the detected metals and cyanide results for soil boring and XRF-screened samples, respectively. Table S-10 in Appendix S-10 presents the full set of soil metals and cyanide results for the soil boring samples. Analytical results are discussed for six individual analyte groups: arsenic, cadmium, lead, mercury, zinc, and cyanide. In addition, analytical results for other analytes detected also are discussed under a general category called “other metals.” Because of the large number of analytical detections and concentrations exceeding the US EPA RREL and IREL, results for the individual metal analytes are discussed below based on the number of RSL exceedances.

Arsenic

All 230 surface soil and all 145 subsurface soil samples collected from Investigation Area 3 were analyzed by the CLP laboratory or screened using the XRF analyzer for arsenic (Figures 4.2.2-2a and 4.2.2-2b). The RREL and IREL for arsenic are 0.39 and 1.6 mg/kg, respectively. The BTVs for arsenic in surface and subsurface soils are 10.7 and 12.44 mg/kg, respectively. Both BTVs were above both the RREL and IREL.

- A total of 192 surface soil sample results (84 percent) and 190 surface soil sample results (83 percent) exceeded the RREL and IREL, respectively. One-hundred-fifty-one surface soil sample results (66 percent) exceeded the surface soil BTV.

- A total of 137 subsurface soil sample results (94 percent) and 133 subsurface soil sample results (92 percent) exceeded the RSSL and IRSL, respectively. Sixty-one subsurface soil sample results (42 percent) exceeded the subsurface soil BTV.
- The maximum detected surface soil arsenic concentration was 810 mg/kg in sample SB047A composed of sinter and slag materials.
- The maximum detected subsurface soil arsenic concentration was 528 mg/kg in sample SB038B collected from 2 to 4 ft bgs composed of sinter and slag materials.

Within Investigation Area 3, a total of 375 soil samples were analyzed or screened for arsenic, of which 88 percent exceeded at least one RSL. Arsenic in soil exceeded the BTV in 57 percent of the total samples in Investigation Area 3. Arsenic contamination is ubiquitous throughout Investigation Area 3 and is prevalent in both native and fill materials, with the highest concentrations detected in surface soils. The surface soils in the northeastern and northwestern portions of Investigation Area 3 were below the arsenic surface BTV and arsenic has been adequately defined to the OU2 boundary. The subsurface soils that exceeded the arsenic BTV is a smaller area than the surface soils. Overall, for the purposes of the RI, arsenic has been delineated horizontally and vertically in Investigation Area 3. Figures 4.2.2-2c and 4.2.2-2d show the surface and subsurface extents of arsenic-impacted soil, respectively.

Cadmium

All 230 surface soil and all 145 subsurface soil samples collected from Investigation Area 3 were analyzed by the CLP laboratory or screened using the XRF analyzer for cadmium (Figures 4.2.2-3a and 4.2.2-3b). The RSSL and IRSL for cadmium are 70 and 800 mg/kg, respectively. The BTVs for cadmium in surface and subsurface soils are 7.1 and 4.68 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- A total of 119 surface soil sample results (52 percent) and one surface soil sample result (0.4 percent) exceeded the RSSL and IRSL, respectively.
- A total of 23 subsurface soil sample results (16 percent) exceeded the RSSL. No subsurface soil sample results exceeded the IRSL.
- The maximum detected surface soil cadmium concentration was 1,020 mg/kg in sample SB025A composed of sand and clay.
- The maximum detected subsurface soil cadmium concentration was 770 mg/kg in sample SB055B collected from 4 to 6 ft bgs composed of silty clay, slag, and fill materials.

Within Investigation Area 3, a total of 375 soil samples were analyzed or screened for cadmium, of which 37 percent exceeded at least one RSL. Cadmium was prevalent in both native and fill materials in surface soil throughout Investigation Area 3. Cadmium in surface and subsurface soils has been adequately defined to the OU2 boundary in Investigation Area 3. Figure 4.2.2-3c and shows the surface extent of cadmium-impacted soil. No subsurface soils exceeded the IRSLs for cadmium within the OU2 boundary. Therefore, a subsurface extent of cadmium-impacted soil figure was not prepared.

Lead

All 230 surface soil and all 145 subsurface soil samples collected from Investigation Area 3 were analyzed by the CLP laboratory or screened using the XRF analyzer for lead (Figures 4.2.2-4a and 4.2.2-4b). The RRSL and IRSL for lead are 400 and 800 mg/kg, respectively. The BTVs for lead in surface and subsurface soils are 103 and 66.1 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- A total 161 surface soil sample results (70 percent) and 136 surface soil sample results (59 percent) exceeded the RRSL and IRSL, respectively.
- A total 51 subsurface soil sample results (35 percent) and 41 subsurface soil sample results (29 percent) exceeded the RRSL and IRSL, respectively.
- The maximum detected surface soil lead concentration was 209,000 mg/kg in sample SB025A composed of sand and clay.
- The maximum detected subsurface soil lead concentration was 62,600 mg/kg in sample SB043B collected from 4 to 5 ft bgs composed of sinter and slag materials.

Within Investigation Area 3, a total of 375 soil samples were analyzed or screened for lead, of which 57 percent exceeded at least one RSL. Lead was ubiquitous in surface soil samples, consisting largely of native and fill materials, throughout Investigation Area 3. The lead-impacted surface soil area is much larger than the lead-impacted subsurface soil area. For the purposes of the RI, lead has been delineated horizontally and vertically in Investigation Area 3. Figures 4.2.2-4c and 4.2.2-4d show the surface and subsurface extents of lead-impacted soil, respectively.

Mercury

A total of 166 surface soil and all 145 subsurface soil samples collected from Investigation Area 3 were analyzed by the CLP laboratory for mercury (Figures 4.2.2-5a and 4.2.2-5b). In addition, 22 of the XRF-

screened samples were submitted to the CLP laboratory for analysis for mercury. The RSSL and IRSL for mercury are 5.6 and 34 mg/kg, respectively. The BTVs for mercury in surface and subsurface soils are 1.32 and 1.33 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- A total of 41 surface soil sample results (25 percent) and 16 surface soil sample results (9 percent) exceeded the RSSL and IRSL, respectively.
- A total of 7 subsurface soil sample results (5 percent) and 3 subsurface soil sample results (2 percent) exceeded the RSSL and IRSL, respectively.
- The maximum detected surface soil mercury concentration was 154 mg/kg in sample SB020A composed of silty soil.
- The maximum detected subsurface soil mercury concentration was 145 mg/kg in sample SB043B collected from 4 to 5 ft bgs composed of sinter and slag materials.

Within Investigation Area 3, a total of 333 soil samples were analyzed for mercury, of which 15 percent exceeded at least one RSL. Mercury was detected in both native and fill materials in surface soil. Most mercury-impacted surface soils IRSL exceedances are located along former railroad grades in Investigation Area 3. Mercury is more prevalent in the surface soils, although the mercury-impacted subsurface soils are associated with the detected exceedances in the surface. The extent of mercury-impacted surface soil has been adequately defined in Investigation Area 3. Figures 4.2.2-5c and 4.2.2-5d show the surface and subsurface extents of mercury-impacted soil, respectively.

Zinc

All 230 surface soil and all 145 subsurface soil samples collected from Investigation Area 3 were analyzed by the CLP laboratory or screened using the XRF analyzer for zinc (Figures 4.2.2-6a and 4.2.2-6b). The RSSL and IRSL for zinc are 23,000 and 310,000 mg/kg, respectively. The BTVs for zinc in surface and subsurface soils are 1,310 and 740 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- A total of 93 surface soil sample results (40 percent) exceeded the RSSL. No surface soil sample results exceeded the IRSL.
- A total of 24 subsurface soil sample results (17 percent) exceeded the RSSL. No subsurface soil sample results exceeded the IRSL.
- The maximum detected surface soil zinc concentration was 218,000 mg/kg in sample SB322A (a duplicate sample of SB117A) composed of sandy clay and slag materials.

- The maximum detected subsurface soil zinc concentration was 98,100 mg/kg in sample SB456B-08 collected from 6 to 8 ft bgs composed of slag, sinter, and fill materials.

Within Investigation Area 3, a total of 375 soil samples were analyzed or screened for zinc, of which 31 percent exceeded the RRSL. Zinc was detected in both the native and fill materials in surface and subsurface soil throughout Investigation Area 3 but more prevalently in surface soil. The zinc-impacted surface soil areas, only exceeded the RRSLs, and are ubiquitous in the former main industrial area (Investigation Area 3). Zinc in surface soils have been adequately defined to the OU2 boundary in Investigation Area 3. Horizontally, subsurface soils may need further delineation to the east of building 1943 next to the OU1 Slag Pile in Investigation Area 3. No surface or subsurface soils exceeded the IRSLS for zinc within the OU2 boundary. Therefore, surface and subsurface zinc-impacted soil figures were not prepared.

Other Metals

“Other metals” are a secondary group comprising metals detected more often than not in the soil samples. However, the spatial extents of these detected metals are not as great or the metal is not as potentially harmful as the metals individually discussed above (arsenic, cadmium, lead, mercury, and zinc). “Other metals” does not include the metals individually discussed above nor the nutrient metals that do not have exceedance criteria (calcium, magnesium, potassium, and sodium). The secondary group of metals includes aluminum, antimony, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, thallium, and vanadium. Iron results are discussed only when results exceeded the IRSLS.

A total of 166 surface soil samples and all 145 subsurface soil samples collected from Investigation Area 3 were analyzed by the CLP laboratory for other metals, and 22 surface soil samples screened using the XRF analyzer were submitted to the laboratory for other metals analysis (Figures 4.2.2-7a and 4.2.2-7b). Tables 4.2.2-1a and 4.2.2-1b summarize the detected other metals results for Investigation Area 3 and list the RRSL and IRSLS for each of the other metals. Investigation Area 3 soil sample results exceeded the RRSL or IRSLS for the following compounds: antimony, cobalt, copper, manganese, selenium, and thallium. RSLs and results for each metal are summarized below. Please note, the December 2009 RSLs were used for all metals except total chromium and thallium. Chromium and thallium results were compared to the April 2009 RSLs.

Antimony

The RRS� and IRS� for antimony are 31 and 410 mg/kg, respectively. The BTV for antimony in surface soils was not developed. The BTV for antimony in subsurface soils is 1.05 mg/kg, and is below both the RSLs.

- A total of 28 surface soil sample results (15 percent) and 6 surface soil sample results (3 percent) exceeded the RRS� and IRS�, respectively.
- A total of five subsurface soil sample results (3 percent) and three subsurface soil sample results (2 percent) exceeded the RRS� and IRS�, respectively.
- The maximum detected surface soil antimony concentration was 660 mg/kg in sample SB182A composed of sinter and slag materials.
- The maximum detected subsurface soil antimony concentration was 621 mg/kg in sample SB181B collected from 8 to 10 ft bgs composed of silty clay and clay.

Soil boring SB182 is located south of Building 1943, and soil boring SB181 is located just northwest of SB182.

Cobalt

The RRS� and IRS� for cobalt are 23 and 300 mg/kg, respectively. The BTVs for cobalt in surface and subsurface soils are 12.9 and 13.8 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- A total of 45 surface soil sample results (24 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- A total of 22 subsurface soil sample results (15 percent) exceeded the RRS�. No subsurface soil sample results exceeded the IRS�.
- The maximum detected surface soil cobalt concentration was 190 mg/kg in sample SB183A composed of fill materials.
- The maximum detected subsurface soil cobalt concentration was 211 mg/kg in sample SB185B collected from 8 to 10 ft bgs composed of slag and fill materials.

Soil boring SB183 is located south of Building 1943, and soil boring SB185 is located at the southeast corner of Building 1943.

Copper

The RRS� and IRS� for copper are 3,100 and 41,000 mg/kg, respectively. The BTVs for copper in surface and subsurface soils are 31.5 and 35.9 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- A total of four surface soil sample results (2 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- No subsurface soil sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected surface soil copper concentration was 7,020 mg/kg in sample SB041A composed of silty sand and sand.
- The maximum detected subsurface soil copper concentration was 2,430 mg/kg in sample SB038B collected from 2 to 4 ft bgs composed of sinter and slag materials.

Soil boring SB041 is located in the central portion of Investigation Area 3 and soil boring SB038 is located southwest of SB041.

Manganese

The RRS� and IRS� for manganese are 1,800 and 23,000 mg/kg, respectively. The BTVs for manganese in surface and subsurface soils are 1,527 and 2,726 mg/kg, respectively. The surface BTV is below the RSLs and the subsurface BTV was above the RRS� but below the IRS�.

- A total of 19 surface soil sample results (10 percent) and 2 surface soil sample results (1 percent) exceeded the RRS� and IRS�, respectively.
- A total of 21 subsurface soil sample results (14 percent) exceeded the RRS�. Of the 21 subsurface soil samples that exceeded the RRS�, 12 were below the subsurface BTV. No subsurface soil sample results exceeded the IRS�.
- The maximum detected surface soil manganese concentration was 43,500 mg/kg in sample SB185A composed of fill material.
- The maximum detected subsurface soil manganese concentration was 7,550 mg/kg in sample SB063B collected from 4 to 6 ft bgs composed of silty clay materials.

Soil boring SB185 is located at the southeast corner of Building 1943, and soil boring SB063 is located near the acid baths in the northern portion of Investigation Area 3.

Selenium

The RRS� and IRS� for selenium are 390 and 5,100 mg/kg, respectively. Surface and subsurface BTVs were not developed for thallium (Appendix RA-2).

- One surface soil sample result (0.5 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- No subsurface soil sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected surface soil selenium concentration was 526 mg/kg in sample SB020A composed of silty soil.
- The maximum detected subsurface soil selenium concentration was 211 mg/kg in sample SB092B collected from 4 to 6 ft bgs composed of sand.

Soil boring SB020 is located in the northwestern portion of Investigation Area 3 and soil boring SB092 is located at the northwestern corner of the furnace building structure.

Thallium

The RRS� and IRS� for thallium are 5.1 and 66 mg/kg, respectively. Surface and subsurface BTVs were not developed for thallium (Appendix RA-2).

- One surface soil sample result (0.5 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- One subsurface soil sample result (0.7 percent) exceeded the RRS�. No subsurface soil sample results exceeded the IRS�.
- The maximum detected surface soil thallium concentration was 9.1 mg/kg in sample SB035A composed of fill materials.
- The maximum detected subsurface soil thallium concentration was 6 mg/kg in sample SB137B collected from 4 to 6 ft bgs composed of fill materials.

Soil boring SB035 is located in the middle of Investigation Area 3 and soil boring SB137 is located in the southwestern portion of Investigation Area 3 north of the Rolling Mill building.

Within Investigation Area 3, a total of 333 soil samples were analyzed for “other metals,” of which 39 percent exceeded at least one RSL. The “other metals” exceeding the RSLs were antimony, cobalt, copper, manganese, selenium, and thallium. The “other metals” exceedances were not localized but were

scattered throughout Investigation Area 3. Most other metals exceedances were associated with surface soil consisting of fill and native materials. The “other metals” surface and subsurface soils have been adequately defined within Investigation Area 3. Figures 4.2.2-7c and 4.2.2-7d show the surface and subsurface extents of other metals-impacted soil, respectively.

Cyanide

A total of 166 surface soil and all 145 subsurface soil samples collected from Investigation Area 3 were analyzed by the CLP laboratory for cyanide, and 22 XRF-screened surface soil samples were submitted to the laboratory for cyanide analysis (Figures 4.2.2-7a and 4.2.2-7b). Tables 4.2.2-1a and 4.2.2-1b summarize the detected cyanide results for Investigation Area 3. The RRS� and IRS� for cyanide are 1,600 and 20,000 mg/kg, respectively. Surface and subsurface BTVs were not developed for cyanide (Appendix RA-2).

- No surface or subsurface soil sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected surface soil cyanide concentration was 5 mg/kg in sample poly_4_011 composed of topsoil with fine gravel and organics.
- The maximum detected subsurface soil cyanide concentration was 4.2 mg/kg in sample SB261B (a duplicate of SB044B) collected from 8 to 10 ft bgs and composed of slag, sinter, and fill materials.

VOCs

Of the 230 surface soil samples collected from Investigation Area 3, 156 were analyzed by the CLP laboratory for VOCs (Figure 4.2.2-8a). Of the 145 subsurface soil samples collected from Investigation Area 3, 135 were analyzed by the CLP laboratory for VOCs (Figure 4.2.2-8b). Table 4.2.2-2 summarizes the detected VOC results for all the soil samples and the respective RRS� and IRS� for each VOC. Table S-11 in Appendix S-11 includes the complete VOC results for all the soil samples.

- No surface or subsurface soil sample results (0 percent) exceeded the RRS� or IRS�.

SVOCs

Of the 230 surface soil samples collected from Investigation Area 3, 154 were analyzed by the CLP laboratory for SVOCs (Figure 4.2.2-9a). Of the 145 subsurface soil samples collected from Investigation Area 3, 133 were analyzed by the CLP laboratory for SVOCs (Figure 4.2.2-9b). Table 4.2.2-3

summarizes the detected SVOC results for all surface and subsurface soil samples. Table S-12 in Appendix S-12 includes the complete SVOC results for all soil samples. Most SVOCs were detected in at least one soil sample. Investigation Area 3 soil sample results exceeded the RRS� or IRS� for the following compounds and are discussed below: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, hexachlorobenzene, indeno(1,2,3-cd)pyrene, and naphthalene.

Benzo(a)anthracene

The RRS� and IRS� for benzo(a)anthracene are 150 and 2,100 µg/kg, respectively.

- A total of 74 surface soil sample results (48 percent) and 17 surface soil samples results (11 percent) exceeded the RRS� and IRS�, respectively.
- A total of 14 subsurface soil sample results (11 percent) and 2 subsurface soil sample results (2 percent) exceeded the RRS� and IRS�, respectively.
- The maximum detected surface soil benzo(a)anthracene concentration was 71,000 µg/kg in sample SB098A composed of fill materials.
- The maximum detected subsurface soil benzo(a)anthracene concentration was 29,000 µg/kg in sample SB043B collected from 4 to 5 ft bgs composed of sinter and slag materials.

Soil boring SB098 is located in the eastern portion of the former furnace building structure, and soil boring SB043 is located in the middle of Investigation Area 3, where the majority of former industrial operations occurred.

Benzo(a)pyrene

The RRS� and IRS� for benzo(a)pyrene are 15 and 210 µg/kg, respectively.

- A total of 111 surface soil sample results (72 percent) and 61 surface soil sample results (40 percent) exceeded the RRS� and IRS�, respectively.
- A total of 44 subsurface soil sample results (33 percent) and 8 subsurface soil sample results (6 percent) exceeded the RRS� and IRS�, respectively.
- The maximum detected surface soil benzo(a)pyrene concentration was 46,000 µg/kg in sample SB098A composed of fill materials.
- The maximum detected subsurface soil benzo(a)pyrene concentration was 26,000 µg/kg in sample SB043B collected from 4 to 5 ft bgs composed of sinter and slag materials.

Soil boring SB098 is located in the eastern portion of the former furnace building structure, and soil boring SB043 is located in the middle of Investigation Area 3, where the majority of former industrial operations occurred.

Benzo(b)fluoranthene

The RRS� and IRS� for benzo(b)fluoranthene are 150 and 2,100 µg/kg, respectively.

- A total of 84 surface soil sample results (55 percent) and 20 surface soil sample results (13 percent) exceeded the RRS� and IRS�, respectively.
- A total of 17 subsurface soil sample results (13 percent) 3 subsurface soil sample results (2 percent) exceeded the RRS� and IRS�, respectively.
- The maximum detected surface soil benzo(b)fluoranthene concentration was 80,000 µg/kg in sample SB098A composed of fill materials.
- The maximum detected subsurface soil benzo(b)fluoranthene concentration was 33,000 µg/kg in sample SB043B collected from 4 to 5 ft bgs composed of sinter and slag materials.

Soil boring SB098 is located in the eastern portion of the former furnace building structure, and soil boring SB043 is located in the middle of Investigation Area 3, where the majority of former industrial operations occurred.

Benzo(g,h,i)perylene

The RRS� and IRS� for benzo(g,h,i)perylene are 150 and 2,100 µg/kg, respectively.

- A total of 50 surface soil sample results (32 percent) and 5 surface soil sample results (3 percent) exceeded the RRS� and IRS�, respectively.
- A total of eight subsurface soil sample results (6 percent) and one subsurface soil sample result (0.8 percent) exceeded the RRS� and IRS�, respectively.
- The maximum detected surface soil benzo(g,h,i)perylene concentration was 36,000 µg/kg in sample SB054A composed of fill materials.
- The maximum detected subsurface soil benzo(g,h,i)perylene concentration was 14,000 µg/kg in sample SB043B collected from 4 to 5 ft bgs composed of sinter and slag materials.

Soil borings SB054 and SB043 are located in the middle of Investigation Area 3, where the majority of former industrial operations occurred.

Benzo(k)fluoranthene

The RRSL and IRSL for benzo(k)fluoranthene are 1,500 and 21,000 µg/kg, respectively.

- A total of 11 surface soil sample results (7 percent) and 1 surface soil sample result (0.6 percent) exceeded the RRSL and IRSL, respectively.
- A total of two subsurface soil sample results (2 percent) exceeded the RRSL. No subsurface soil sample results exceeded the IRSL.
- The maximum detected surface soil benzo(k)fluoranthene concentration was 32,000 µg/kg in sample SB054A composed of fill materials.
- The maximum detected subsurface soil benzo(k)fluoranthene concentration was 11,000 µg/kg in sample SB043B collected from 4 to 5 ft bgs composed of sinter and slag materials.

Soil borings SB054 and SB043 are located in the middle of Investigation Area 3, where the majority of former industrial operations occurred.

Chrysene

The RRSL and IRSL for chrysene are 15,000 and 210,000 µg/kg, respectively.

- A total of four surface soil sample results (3 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- One subsurface soil sample result (0.7 percent) exceeded the RRSL. No subsurface soil sample results exceeded the IRSL.
- The maximum detected surface soil chrysene concentration was 63,000 µg/kg in sample SB098A composed of fill materials.
- The maximum detected subsurface soil chrysene concentration was 26,000 µg/kg in sample SB043B collected from 4 to 5 ft bgs composed of sinter and slag materials.

Soil boring SB098 is located in the eastern portion of the former furnace building structure, and soil boring SB043 is located in the middle of Investigation Area 3.

Dibenzo(a,h)anthracene

The RRSL and IRSL for dibenzo(a,h)anthracene are 15 and 210 µg/kg, respectively.

- A total of 59 surface soil sample results (38 percent) and 19 surface soil sample results (12 percent) exceeded the RRS� and IRS�, respectively.
- A total of 10 subsurface soil sample results (8 percent) and 3 subsurface soil sample results (2 percent) exceeded the RRS� and IRS�, respectively.
- The maximum detected surface soil dibenzo(a,h)anthracene concentration was 7,700 µg/kg in sample SB098A composed of fill materials.
- The maximum detected subsurface soil dibenzo(a,h)anthracene concentration was 4,200 µg/kg in sample SB043B collected from 4 to 5 ft bgs composed of sinter and slag materials.

Soil boring SB098 is located in the eastern portion of the former furnace building structure, and soil boring SB043 is located in the middle of Investigation Area 3.

Hexachlorobenzene

The RRS� and IRS� for hexachlorobenzene are 300 and 1,100 µg/kg, respectively.

- One surface soil sample result (0.6 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- No subsurface soil sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected surface soil hexachlorobenzene concentration was 330 µg/kg in sample SB093A composed of fill materials.
- Hexachlorobenzene was not detected in any of the Investigation Area 3 subsurface soil samples.

Soil boring SB093 is located at the western portion of the former furnace building structure.

Indeno(1,2,3-cd)pyrene

The RRS� and IRS� for indeno(1,2,3-cd)pyrene are 150 and 2,100 µg/kg, respectively.

- A total of 62 surface soil sample results (40 percent) and 6 surface soil sample results (4 percent) exceeded the RRS� and IRS�, respectively.
- Eight subsurface soil sample results (6 percent) and two subsurface soil sample results (2 percent) exceeded the RRS� and IRS�, respectively.
- The maximum detected surface soil indeno(1,2,3-cd)pyrene concentration was 26,000 µg/kg in sample SB098A composed of fill materials.

- The maximum detected subsurface soil indeno(1,2,3-cd)pyrene concentration was 20,000 µg/kg in sample SB043B collected from 4 to 5 ft bgs composed of sinter and slag materials.

Soil boring SB098 is located in the eastern portion of the former furnace building structure, and soil boring SB043 is located in the middle of Investigation Area 3.

Naphthalene

The RRS� and IRS� for naphthalene are 3,600 and 18,000 µg/kg, respectively.

- Three surface soil sample results (2 percent) and one surface soil sample result (0.6 percent) exceeded the RRS� and IRS�, respectively.
- One subsurface soil sample result (0.8 percent) exceeded the RRS�. No subsurface soil sample results exceeded the IRS�.
- The maximum detected surface soil naphthalene concentration was 20,000 µg/kg in sample SB098A composed of fill materials.
- The maximum detected subsurface soil naphthalene concentration was 6,800 µg/kg in sample SB043B collected from 4 to 5 ft bgs composed of sinter and slag materials.

Soil boring SB098 is located in the eastern portion of the former furnace building structure, and soil boring SB043 is located in the middle of Investigation Area 3.

Within Investigation Area 3, a total of 287 soil samples were analyzed for SVOCs, of which 55 percent exceeded at least one RSL. Of the 154 soil boring locations sampled for SVOCs, results for samples from 112 locations (73 percent) exceeded at least one RSL. Most of Investigation Area 3 samples contain surface slag, sinter, or fill materials. Generally, SVOC concentrations were higher in surface soil than in subsurface soil. SVOC-impacted surface soil is seemingly associated with former industrial operations as impacted soils are within the proximity of former operations structures across Investigation Area 3. The highest surface soil concentrations are located in the central portion of the former main industrial area (SB054) and near the former furnace building structure (SB098 and SB093). SVOC-impacted subsurface soil generally is localized in the central portion of Investigation Area 3 and in the vicinity of the former furnace building structures. The boring location with the highest subsurface soil SVOC concentrations was SB043. SVOCs were detected in the subsurface in both native and fill materials at Investigation Area 3. For the purposes of this RI, SVOCs in surface and subsurface soils are adequately delineated. However, soils may need further delineation in the northeastern area of Investigation Area 3, northeast of

SB075. Figures 4.2.2-9c and 4.2.2-9d show the surface and subsurface extents of SVOC-impacted soil, respectively.

PCBs

Of the 230 surface soil samples collected from Investigation Area 3, 154 were analyzed by the CLP laboratory for PCBs (Figure 4.2.2-10a). Of the 145 total subsurface soil samples collected from Investigation Area 3, 133 were analyzed by the CLP laboratory for PCBs (Figure 4.2.2-10b). Table 4.2.2-4a summarizes the detected PCB results for all the soil samples. Table S-13 in Appendix S-13 presents the full set of soil PCB results. Results for the following PCB compounds exceeded the RRS� and IRS� and are discussed below: Aroclor-1254, Aroclor-1260, and Aroclor-1262.

Aroclor-1254

The RRS� and IRS� for Aroclor-1254 are 220 and 740 µg/kg, respectively.

- Five surface soil sample results (3 percent) and two surface soil sample results (1 percent) exceeded the RRS� and IRS�, respectively.
- One subsurface soil sample result (0.8 percent) exceeded both the RRS� and IRS�.
- The maximum detected surface soil Aroclor-1254 concentration was 1,200 µg/kg in sample SB185A composed of fill materials.
- The maximum detected subsurface soil Aroclor-1254 concentration was 1,100 µg/kg in sample SB214B collected from 6 to 8 ft bgs and composed of slag and fill materials.

Soil boring SB185 is located at the southeastern corner of Building 1943, and soil boring SB214 is located on the western edge of Investigation Area 3 along Investigation Area 1.

Aroclor-1260

The RRS� and IRS� for Aroclor-1260 are 220 and 740 µg/kg, respectively.

- Three surface soil sample results (2 percent) and one surface soil sample result (0.6 percent) exceeded the RRS� and IRS�, respectively.
- No subsurface soil sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected surface soil Aroclor-1260 concentration was 1,200 µg/kg in sample SB185A composed of fill materials.

- The maximum detected subsurface soil Aroclor-1260 concentration was 120 µg/kg in sample SB185B composed of slag and fill materials.

Soil boring SB185 is located at the southeastern corner of Building 1943.

Aroclor-1262

The RRS� and IRS� for Aroclor-1262 are 220 and 740 µg/kg, respectively.

- One surface soil sample result (0.6 percent) exceeded the RRS� and IRS�.
- No subsurface soil sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected surface soil Aroclor-1262 concentration was 230 µg/kg in sample SB041A composed of silty sand and sand.
- Aroclor-1262 was not detected in any of the Investigation Area 3 subsurface soil samples.

Soil boring SB041 is located in the central portion of the former main industrial area.

Within Investigation Area 3, a total of 287 soil samples were analyzed for PCBs, of which 3 percent exceeded at least one RSL. PCB concentrations in seven surface and one subsurface soil boring locations exceeded at least one RSL for at least one PCB compound. These eight soil boring locations are not localized and are scattered throughout Investigation Area 3. For the purposes of this RI, surface and subsurface soils have been adequately defined for PCBs in Investigation Area 3. Figures 4.2.2-10c and 4.2.2-10d show the surface and subsurface extents of PCB-impacted soil, respectively.

Pesticides

Of the 230 surface soil samples collected from Investigation Area 3, 154 were analyzed by the CLP laboratory for pesticides (Figure 4.2.2-11a). Of the 145 total subsurface soil samples collected from Investigation Area 3, 133 were analyzed by the CLP laboratory for pesticides (Figure 4.2.2-11b). Table 4.2.2-5 summarizes the detected pesticide results for all the soil samples. Table S-14 in Appendix S-14 presents the full set of soil pesticide results. All pesticide compounds were detected in at least one soil sample. Results for the pesticide compound dieldrin exceeded the RRS� and are discussed below.

Dieldrin

The RRS� and IRS� for dieldrin are 30 and 110 µg/kg, respectively.

- One surface soil sample result (0.6 percent) exceeded the RSSL. No surface soil sample results exceeded the IRSL.
- No subsurface soil sample results exceeded the RSSLs or IRSLs.
- The maximum detected surface soil dieldrin concentration was 47 µg/kg in sample SB043A composed of fill materials.
- The maximum detected subsurface soil dieldrin concentration was 7.6 µg/kg in sample SB044B collected from 8 to 10 ft bgs composed of slag, sinter, and fill materials.

Soil boring SB043 is located in the central portion of the former main industrial area.

Within Investigation Area 3, a total of 287 soil samples were analyzed for pesticides, of which 0.3 percent exceeded the RSSL. Only one result for a surface soil sample collected from soil boring SB043 in the central portion of the former main industrial area exceeded the RSSL. The nature and extent of pesticides-impacted soil has been adequately defined both horizontally and vertically. No surface or subsurface soils exceeded the IRSLs for pesticides within the OU2 boundary. Therefore, surface and subsurface pesticide-impacted soil figures were not prepared.

Asbestos

Of the 230 surface soil samples collected from Investigation Area 3, 155 were analyzed by STAT Laboratories for asbestos (Figure 4.2.2-12). Of the 154 subsurface soil samples collected from Investigation Area 3, 22 were analyzed by STAT Laboratories for asbestos. Table 4.2.2-6 summarizes the asbestos results for all the soil samples. Table S-15 in Appendix S-15 presents the full set of soil asbestos results.

- Eleven surface soil sample results (7 percent) were detected above the 0.25 percent detection limit.
- No subsurface soil sample results (0 percent) were detected above the 0.25 percent detection limit.
- The maximum detected percentage of asbestos in a surface soil sample was 3.75 percent in sample SB030A composed of fill materials.

Within Investigation Area 3, a total of 177 soil samples were analyzed for asbestos, of which 6 percent contained asbestos fibers of 0.25 percent or more. Asbestos was detected in surface soil samples only, mostly from the central portion of Investigation Area 3. Results for samples collected from the vicinity of the furnace building structure and west of the river pump house also exceeded the asbestos detection limit

of 0.25 percent. The nature and extent of asbestos-impacted soil has been adequately defined both horizontally and vertically in Investigation Area 3.

TCLP Metals

A total of five surface soil and five subsurface soil samples collected from Investigation Area 3 were analyzed by the CLP laboratory for TCLP metals (Figures 4.2.2-13a and 4.2.2-13b). Table 4.2.2-7 summarizes the detected TCLP metals results for all the soil samples. Table S-16 in Appendix S-16 presents the full set of soil TCLP metals results. TCLP metals results for cadmium and lead exceeded the regulatory levels presented in 40 CFR §261.24 and are discussed below.

Cadmium

The regulatory level for TCLP cadmium is 1,000 µg/L.

- Two surface soil sample results (40 percent) exceeded the regulatory level.
- No subsurface soil sample results (0 percent) exceeded the regulatory level.
- The maximum detected surface soil TCLP cadmium concentration was 1,590 µg/L in sample SB454A-08 composed of slag, sinter, and fill materials.
- The maximum detected subsurface soil TCLP cadmium concentration was 604 µg/L in sample SB454B-08 composed of sinter and slag materials.

Soil boring SB454 is located in the center of the former main industrial area.

Lead

The regulatory level for TCLP lead is 5,000 µg/L.

- Two surface soil sample results (40 percent) exceeded the regulatory level.
- One subsurface soil sample result (20 percent) exceeded the regulatory level.
- The maximum detected surface soil TCLP lead concentration was 37,100 µg/L in sample SB453A-08 composed of native, slag, sinter, and fill materials.
- The maximum detected subsurface soil TCLP lead concentration was 29,900 µg/L in sample SB454B-08 collected from 6 to 8 ft bgs composed of sinter and slag materials.

Soil boring SB453 is located in the north-central portion of Investigation Area 3 just south of the rectangular former lead-lined acid tanks, and soil boring SB454 is located in the center of Investigation Area 3.

Based on the TCLP metals results, sinter and slag in the central portion of Investigation Area 3 exceed toxicity characteristic thresholds.

SPLP Metals

A total of 10 surface soil and 10 subsurface soil samples collected from Investigation Area 3 were analyzed by the CLP laboratory for SPLP metals (Figures 4.2.2-13a and 4.2.2-13b). Tables 4.2.2-8a and 4.2.2-8b summarize the detected SPLP metals results for all the soil samples compared to the 40 CFR §261.24 regulatory levels and the GWSVs, respectively. Tables S-17 and S-18 in Appendices S-17 and S-18 present the full set of soil SPLP metals results. None of the SPLP metals results for surface or subsurface soil samples exceeded the 40 CFR §261.24 regulatory levels, and these results are not discussed further. Results for the following SPLP metals exceeded the GWSVs and are discussed below: antimony, cadmium, lead, and zinc.

Antimony

The GWSV for SPLP antimony is 6 µg/L.

- Three surface soil sample results (30 percent) exceeded the GWSV.
- Five subsurface soil sample results (50 percent) exceeded the GWSV.
- The maximum detected surface soil SPLP antimony concentration was 21.3 µg/L in sample SB505A-08 (a duplicate sample of SB452A-08) composed of silty clay, sinter, and fill materials.
- The maximum detected subsurface soil SPLP antimony concentration was 15.5 µg/L in sample SB456B-08 collected from 6 to 8 ft bgs composed of slag, sinter, and fill materials.

Soil boring SB452 is located west of the cylindrical acid reservoirs in the northern portion of Investigation Area 3. Soil boring SB456 is located approximately 250 ft north of the Rolling Mill building.

Cadmium

The GWSV for SPLP cadmium is 5 µg/L.

- Seven surface soil sample results (70 percent) exceeded the GWSV.
- Five subsurface soil sample results (50 percent) exceeded the GWSV.
- The maximum detected surface soil SPLP cadmium concentration was 762 µg/L in sample SB505A-08 (a duplicate sample of SB452A-08) composed of silty clay, sinter, and fill materials.
- The maximum detected subsurface soil SPLP cadmium concentration was 414 µg/L in sample SB457B-08 collected from 10 to 12 ft bgs composed of slag, sinter, and fill materials.

Soil boring SB452 is located west of the cylindrical acid reservoirs in the northern portion of Investigation Area 3. Soil boring SB457 is located in the southern portion of Investigation Area 3, northwest of the former furnace building structure.

Lead

The GWSV for SPLP lead is 15 µg/L.

- Two surface soil sample results (20 percent) exceeded the GWSV.
- Two subsurface soil sample results (20 percent) exceeded the GWSV.
- The maximum detected surface soil SPLP lead concentration was 116 µg/L in sample SB454A-08 composed of slag, sinter, and fill materials.
- The maximum detected subsurface soil SPLP lead concentration was 414 µg/L in sample SB454B-08 collected from 6 to 8 ft bgs composed of sinter and slag materials.

Soil boring SB454 is located in the center of the former main industrial area.

Zinc

The GWSV for SPLP zinc is 11,000 µg/L.

- Two surface soil sample results (20 percent) exceeded the GWSV.
- Two subsurface soil sample result (20 percent) exceeded the GWSV.
- The maximum detected surface soil SPLP zinc concentration was 74,900 µg/L in sample SB505A-08 (a duplicate sample of SB452A-08) composed of silty clay, sinter, and fill materials.
- The maximum detected subsurface soil SPLP zinc concentration was 39,800 µg/L in sample SB454B-08 collected from 6 to 8 ft bgs composed of sinter and slag materials.

Soil boring SB452 is located west of the cylindrical former acid reservoirs in the northern portion of Investigation Area 3. Soil boring SB454 is located in the center of the former main industrial area.

Within Investigation Area 3, a total of 10 surface soil and 10 subsurface soil samples were analyzed for SPLP metals, of which results for surface and subsurface samples from nine soil boring locations exceeded the GWSVs. Based on these results, migration of metals in native materials, slag, sinter, and fill materials to groundwater is a potential issue.

Investigation Area 3 Summary

Soil sample results for Investigation Area 3 reveal that the following metals were detected at concentrations exceeding the RSLs: arsenic, cadmium, lead, mercury, zinc, antimony, cobalt, copper, manganese, selenium, and thallium. Soil sample results for Investigation Area 3 reveal that the following organic compounds were detected at concentrations exceeding the RSLs: SVOCs (a total of 10 compounds) and PCBs (a total of three compounds). Asbestos also was detected in surface soil at Investigation Area 3. In addition, 10 and 20 soil samples were submitted to the CLP laboratory for TCLP and SPLP metals analysis, respectively, and sample results exceeded the screening criteria. The areas of highest soil impacts (analytes that exceeded the IRSLS) at Investigation Area 3 are summarized below.

The main area of arsenic-impacted surface soil encompasses most of Investigation Area 3 and extends into the other three on-site Investigation Areas (Figure 4.2.2-2c). The highest arsenic concentrations were in the surface soils and in the central portion of Investigation Area 3. The main area of arsenic-impacted subsurface soil is a smaller area than the surface soil footprint and located in the southern portion of Investigation Area 3 (Figure 4.2.2-2d). Several smaller areas of arsenic-impacted subsurface soils exist in the east-central and easternmost portions of Investigation Area 3. The highest cadmium concentrations in surface soil were detected in samples collected from a small area in the west-central portion of Investigation Area 3 (Figure 4.2.2-3c). No subsurface soil sample results exceeded the IRSLS. The main area of lead-impacted surface soil encompasses all of Investigation Area 3 and extends into the other three on-site areas, except for an area near the four acid reservoirs that extends to the western boundary of the Matthiessen and Hegeler Zinc Company Site and the northeastern corner of Investigation Area 3, where lead was detected in the surface soil samples but not at concentrations exceeding the IRSLS (Figure 4.2.2-4c). One main area of lead-impacted subsurface soil exists in the central portion of Investigation Area 3, and this area is surrounded by many smaller areas of lead-impacted subsurface soil (Figure 4.2.2-4d). Eight small areas of mercury-impacted surface soil exist near the west, central, and northeast portions of Investigation Area 1 (Figure 4.2.2-5c). Three small areas of mercury-impacted subsurface soil exist (Figure 4.2.2-5d). Mercury-impacted surface soil exists in all three areas of mercury-impacted subsurface soil. Four small areas of other metals-impacted surface soil exist in the western, central, and southern portions of Investigation Area 3 (Figure 4.2.2-7c). Two small areas of other metals-impacted subsurface

soil exist in the western and southern portions of Investigation Area 3 (Figure 4.2.2-7d). One large area of SVOC-impacted surface soil encompasses most Investigation Area 3, with two smaller areas in the western and southern portions Investigation Area 3 (Figure 4.2.2-9c). Areas of SVOC-impacted subsurface soil are scattered in seven different areas throughout Investigation Area 3 (Figure 4.2.2-9d). Two small areas of PCB-impacted surface soil exist (Figure 4.2.2-10c), and PCB concentrations exceed the IRSL at only one subsurface soil sampling location along the western boundary of Investigation Area 3 (Figure 4.2.2-10d).

4.2.2.4 Investigation Area 4: North Area/Northeast Periphery Area

A total of 131 soil samples were collected from Investigation Area 4, North Area/Northeast Periphery Area (Figure 4.2.2-1a). Of the 131 soil samples, there were 104 total surface soil samples, 27 surface soil boring and 77 surface grab samples, and 27 were subsurface soil boring samples. The surface and subsurface soil total metals and cyanide, VOC, SVOC, PCB, pesticides, asbestos, TCLP metals, and SPLP metals results for Investigation Area 4 are summarized below, followed by a summary of the Investigation Area 4 results.

Metals and Cyanide

Of the 104 (27 soil boring and 77 grab) surface soil samples collected from Investigation Area 4, 27 surface soil boring samples were analyzed for total metals and cyanide. Seventy-seven surface soil samples from Investigation Area 4 were screened using the XRF analyzer for arsenic, cadmium, lead, and zinc. Of the 77 XRF-screened surface samples, 27 were submitted to the CLP laboratory for total metals and cyanide analysis. All 27 subsurface soil samples collected from Investigation Area 4 were analyzed for total metals and cyanide. Tables 4.2.2-1a and 4.2.2-1b summarize the detected metals and cyanide results for the soil boring and XRF-screened samples, respectively. Table S-10 in Appendix S-10 presents the full set of metals and cyanide results for the soil boring samples. Analytical results are discussed for six individual analyte groups: arsenic, cadmium, lead, mercury, zinc, and cyanide. In addition, analytical results for other analytes detected also are discussed under a general category called “other metals.” Because of the large number of analytical detections and concentrations exceeding the US EPA RSL and IRSL, results for the individual metal analytes are discussed below based on the number of RSL exceedances.

Arsenic

All 104 surface soil and all 27 subsurface soil samples collected from Investigation Area 4 were analyzed by the CLP laboratory or screened using the XRF analyzer for arsenic (Figures 4.2.2-2a and 4.2.2-2b). The RSSL and IRSL for arsenic are 0.39 and 1.6 mg/kg, respectively. The BTVs for arsenic in surface and subsurface soils are 10.7 and 12.44 mg/kg, respectively. Both BTVs were above both the RSSL and IRSL.

- A total of 67 surface soil sample results (64 percent) and 65 surface soil sample results (63 percent) exceeded the RSSL and IRSL, respectively. A total of 49 surface soil sample results (47 percent) exceeded the surface soil BTV.
- All 27 subsurface soil sample results (100 percent) exceeded both the RSSL and IRSL. Three subsurface soil sample results (11 percent) exceeded the subsurface soil BTV.
- The maximum detected surface soil arsenic concentration was 129 mg/kg in sample SB450A-08 composed of sinter and fill materials.
- The maximum detected subsurface soil arsenic concentration was 61.4 mg/kg in sample SB115B collected from 8 to 10 ft bgs composed of silty sand and silty clay.

Within Investigation Area 4, a total of 131 soil samples were analyzed or screened for arsenic, of which 72 percent exceeded at least one RSL. Arsenic in soil exceeded the BTV in only 40 percent of the total samples in Investigation Area 4. Arsenic exceeded the BTV in surface soils sporadically throughout Investigation Area 4 with the largest area in the southern portion consisting of a mixture of fill and native materials. Arsenic exceeded the BTV in subsurface soils in only three samples all consisting of native materials. Arsenic-impacted soils seem localized in Investigation Area 4 and are adequately delineated in the surface and subsurface soils. Figures 4.2.2-2c and 4.2.2-2d show the surface and subsurface extents of arsenic-impacted soil, respectively.

Cadmium

All 104 surface soil and all 27 subsurface soil samples collected from Investigation Area 4 were analyzed by the CLP laboratory or screened using the XRF analyzer for cadmium (Figures 4.2.2-3a and 4.2.2-3b). The RSSL and IRSL for cadmium are 70 and 800 mg/kg, respectively. The BTVs for cadmium in surface and subsurface soils are 7.1 and 4.68 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- A total of 39 surface soil sample results (38 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- No subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected surface soil cadmium concentration was 290 mg/kg in sample poly_2_038 composed of topsoil with clay.
- The maximum detected subsurface soil cadmium concentration was 18.1 mg/kg in sample SB115B collected from 8 to 10 ft bgs composed of silty sand and silty clay.

Within Investigation Area 4, a total of 131 soil samples were analyzed or screened for cadmium, of which 30 percent exceeded the RRSL. Results for surface soil samples only exceeded the RSL. Cadmium results for the XRF-screened surface soil samples collected from throughout Investigation Area 4 exceeded the RRSL. Cadmium was not detected at concentrations exceeding the RSLs in subsurface soil within Investigation Area 4. No surface or subsurface soils exceeded the IRSLs for cadmium within Investigation Area 4. Cadmium surface and subsurface soils have been adequately defined in Investigation Area 4.

Lead

All 104 surface soil and all 27 subsurface soil samples collected from Investigation Area 4 were analyzed by the CLP laboratory or screened using the XRF analyzer for lead (Figures 4.2.2-4a and 4.2.2-4b). The RRSL and IRSL for lead are 400 and 800 mg/kg, respectively. The BTVs for lead in surface and subsurface soils are 103 and 66.1 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- A total of 33 surface soil sample results (32 percent) 12 surface soil samples (12 percent) exceeded the RRSL and IRSL, respectively.
- No subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected surface soil lead concentration was 2,508.47 mg/kg in sample poly_1_041 composed of slag, sinter, and fill materials.
- The maximum detected subsurface soil lead concentration was 168 mg/kg in sample SB115B collected from 8 to 10 ft bgs composed of silty sand and silty clay.

Within Investigation Area 4, a total of 131 soil samples were analyzed or screened for lead, of which 25 percent exceeded the RRSL. Only lead results from surface soil samples exceeded the RSLs, while lead was not detected at concentrations exceeding the RSLs in subsurface soils within Investigation Area 4.

Lead in surface soils have been adequately delineated within Investigation Area 4. Lead in subsurface soils may need further investigation in the areas where surface soil sampling locations exceeded the RSLs. Figure 4.2.2-4c shows the surface extent of lead-impacted soil.

Mercury

A total of 54 surface soil and all 27 subsurface soil samples collected from Investigation Area 4 were analyzed by the CLP laboratory for mercury (Figures 4.2.2-5a and 4.2.2-5b). The RRS� and IRS� for mercury are 5.6 and 34 mg/kg, respectively. The BTVs for mercury in surface and subsurface soils are 1.32 and 1.33 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- No surface or subsurface soil sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected surface soil mercury concentration was 2.8 mg/kg in sample poly_2_023 composed of topsoil and sinter.
- The maximum detected subsurface soil mercury concentration was 0.22 mg/kg in sample SB112B collected from 8 to 10 ft bgs composed of clay.

Zinc

All 104 surface soil and all 27 subsurface soil samples collected from Investigation Area 4 were analyzed by the CLP laboratory or screened using the XRF analyzer for zinc (Figures 4.2.2-6a and 4.2.2-6b). The RRS� and IRS� for zinc are 23,000 and 310,000 mg/kg, respectively. The BTVs for zinc in surface and subsurface soils are 1,310 and 740 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- A total of 11 surface soil sample results (11 percent) exceeded the RRS�. No surface soil sample results exceeded the IRS�.
- One subsurface soil sample result (4 percent) exceeded the RRS�. No subsurface soil sample results exceeded the IRS�.
- The maximum detected surface soil zinc concentration was 131,279.8 mg/kg in sample poly_1_043 composed of clay.
- The maximum detected subsurface soil zinc concentration was 41,000 mg/kg in sample SB115B collected from 6 to 8 ft bgs composed of silty sand and silty clay.

Within Investigation Area 4, a total of 131 soil samples were analyzed or screened for zinc, of which 9 percent exceeded the RRS�. Results for surface soil samples collected from the area where Investigation

Area 4 borders Investigation Area 3 exceeded the RRSL. The result for only one subsurface soil sample exceeded the RRSL. This sample was collected north of the northern boundary of Investigation Area 3. Zinc in surface and subsurface soils has been adequately defined in Investigation Area 4. No surface or subsurface soils exceeded the IRSLS for zinc within the OU2 boundary. Therefore, surface and subsurface zinc-impacted soil figures were not prepared.

Other Metals

“Other metals” are a secondary group comprising metals detected more often than not in the soil samples. However, the spatial extents of these detected metals are not as great or the metal is not as potentially harmful as the metals individually discussed above (arsenic, cadmium, lead, mercury, and zinc). “Other metals” does not include the metals individually discussed above nor the nutrient metals that do not have exceedance criteria (calcium, magnesium, potassium, and sodium). The secondary group of metals includes aluminum, antimony, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, thallium, and vanadium. Iron results are discussed only when results exceeded the IRSL.

A total of 27 surface soil and 27 subsurface soil samples collected from Investigation Area 4 were analyzed by the CLP laboratory for other metals, and 27 XRF-screened surface soil samples were submitted to the laboratory for other metals analysis (Figures 4.2.2-7a and 4.2.2-7b). Tables 4.2.2-1a and 4.2.2-1b summarize the detected other metals results for Investigation Area 4 and list the RRSL and IRSL for each of the other metals. Investigation Area 4 soil sample results exceeded the RRSL or IRSL for the following compounds: cobalt and manganese. RSLs and results for each metal are summarized below. Please note, the December 2009 RSLs were used for all metals except total chromium and thallium. Chromium and thallium results were compared to the April 2009 RSLs.

Cobalt

The RRSL and IRSL for cobalt are 23 and 300 mg/kg, respectively. The BTVs for cobalt in surface and subsurface soils are 12.9 and 13.8 mg/kg, respectively. Both the surface and subsurface BTVs are below the RSLs.

- Four surface soil sample results (4 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- Two subsurface soil sample results (7 percent) exceeded the RRSL. No subsurface soil sample results exceeded the IRSL.

- The maximum detected surface soil cobalt concentration was 51.1 mg/kg in sample SB450A-08 composed of sinter and fill materials.
- The maximum detected subsurface soil cobalt concentration was 79.5 mg/kg in sample SB448B-08 collected from 8 to 10 ft bgs composed of silty clay.

Soil boring SB450 is located in the southern portion of Investigation Area 4 near the Investigation Area 3 border, and soil boring SB448 is located in the north-central portion of Investigation Area 4.

Manganese

The RRSL and IRSL for manganese are 1,800 and 23,000 mg/kg, respectively. The BTVs for manganese in surface and subsurface soils are 1,527 and 2,726 mg/kg, respectively. The surface BTV is below the RSLs and the subsurface BTV was above the RRSL but below the IRSL.

- No surface soil sample results (0 percent) exceeded the RRSL or IRSL.
- Three subsurface soil sample results (11 percent) exceeded the RRSL. Of the three subsurface soil samples that exceeded the RRSL, two were below the BTV. No subsurface soil sample results exceeded that IRSL.
- The maximum detected surface soil manganese concentration was 1,400 mg/kg in sample SB445A-08 composed of clay and sand.
- The maximum detected subsurface soil manganese concentration was 2,980 mg/kg in sample SB429B-08 collected from 4 to 6 ft bgs composed of silty clay and limestone.

Soil boring SB445 is located approximately 340 ft north of the northern boundary of Investigation Area 3, along the eastern boundary of OU2. Soil boring SB429 is located approximately 300 ft north of the northern border of Investigation Area 3 and 340 ft west of the eastern boundary of OU2.

Within Investigation Area 4, a total of 54 soil samples were analyzed for “other metals,” of which 13 percent exceeded at least one RSL. The “other metals” exceeding the RSLs were cobalt and manganese. Surface and subsurface “other metals”-impacted soil have been delineated both vertically and horizontally within Investigation Area 4. No surface or subsurface soil results exceeded the IRSLs for “other metals” within Investigation Area 4.

Cyanide

Fifty-four surface soil and all 27 subsurface soil samples collected from Investigation Area 4 were analyzed by the CLP laboratory for cyanide (Figures 4.2.2-7a and 4.2.2-7b). The RRSL and IRSL for cyanide are 1,600 and 20,000 mg/kg, respectively. Surface and subsurface BTVs were not developed for cyanide (Appendix RA-2).

- No surface or subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected surface soil cyanide concentration was 2.5 mg/kg in sample poly_2_201 (a duplicate sample of poly_2_055) composed of clay.
- The maximum detected subsurface soil cyanide concentration was 0.38 mg/kg in sample SB105B collected from 4 to 6 ft bgs composed of fill materials.

VOCs

Of the 104 surface soil samples collected from Investigation Area 4, 27 were analyzed by the CLP laboratory for VOCs (Figure 4.2.2-8a). All 27 subsurface soil samples collected from Investigation Area 4 were analyzed by the CLP laboratory for VOCs (Figure 4.2.2-8b). Table 4.2.2-2 summarizes the detected VOC results for all the soil samples and the respective RRSL and IRSL for each compound. Table S-11 in Appendix S-11 includes the complete VOC results for all the soil samples.

- No surface or subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.

SVOCs

Of the 104 surface soil samples collected from Investigation Area 4, 27 were analyzed by the CLP laboratory for SVOCs (Figure 4.2.2-9a). All 27 subsurface soil samples collected from Investigation Area 4 were analyzed by the CLP laboratory for VOCs (Figure 4.2.2-9b). Table 4.2.2-3 summarizes the detected SVOC results for all surface and subsurface soil samples. Table S-12 in Appendix S-12 includes the complete SVOC results for all soil samples. Approximately 30 percent of the SVOCs were detected in at least one soil sample. Investigation Area 4 results for the following compounds exceeded the RRSLs and are discussed below: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

Benzo(a)anthracene

The RRSL and IRSL for benzo(a)anthracene are 150 and 2,100 µg/kg, respectively.

- One surface soil sample result (4 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- No subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected surface soil benzo(a)anthracene concentration was 180 µg/kg in sample SB106A composed of sinter and slag materials.
- The maximum detected subsurface soil benzo(a)anthracene concentration was 41 µg/kg in sample SB444B collected from 8 to 10 ft bgs composed of slag and fill materials.

Soil boring SB106 is located off-site past the northern boundary of OU2. Soil boring SB444 is located approximately 350 ft north of the northern boundary of Investigation Area 3 and 200 ft west of the eastern boundary of OU2.

Benzo(a)pyrene

The RRSL and IRSL for benzo(a)pyrene are 15 and 210 µg/kg, respectively.

- Two surface soil sample results (7 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- One subsurface soil sample result (4 percent) exceeded the RRSL. No subsurface soil sample results exceeded the IRSL.
- The maximum detected surface soil benzo(a)pyrene concentration was 200 µg/kg in sample SB106A composed of sinter and slag materials.
- The maximum detected subsurface soil benzo(a)pyrene concentration was 20 µg/kg in sample SB104B collected from 8 to 10 ft bgs composed of shale and limestone.

Soil boring SB106 is located off-site past the northern boundary of OU2, and soil boring SB104 is located along the former railroad tracks.

Benzo(b)fluoranthene

The RRSL and IRSL for benzo(b)fluoranthene are 150 and 2,100 µg/kg, respectively.

- One surface soil sample result (4 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- No subsurface soil sample results (0 percent) exceeded the RRSLs or IRSLs.

- The maximum detected surface soil benzo(b)fluoranthene concentration was 510 µg/kg in sample SB106A composed of sinter and slag materials.
- The maximum detected subsurface soil benzo(b)fluoranthene concentration was 32 µg/kg in sample SB104B collected from 8 to 10 ft bgs composed of shale and limestone.

Soil boring SB106 is located off-site past the northern boundary of OU2, and soil boring SB104 is located along the former railroad tracks.

Benzo(g,h,i)perylene

The RRSL and IRSL for benzo(g,h,i)perylene are 150 and 2,100 µg/kg, respectively.

- One surface soil sample result (4 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- No subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected surface soil benzo(g,h,i)perylene concentration was 200 µg/kg in sample SB106A composed of sinter and slag materials.
- The maximum detected subsurface soil benzo(g,h,i)perylene concentration was 40 µg/kg in sample SB104B collected from 8 to 10 ft bgs composed of shale and limestone.

Soil boring SB106 is located off-site past the northern boundary of OU2, and soil boring SB104 is located along the former railroad tracks.

Dibenzo(a,h)anthracene

The RRSL and IRSL for dibenzo(a,h)anthracene are 15 and 210 µg/kg, respectively.

- One surface soil sample result (4 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- No subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected surface soil dibenzo(a,h)anthracene concentration was 76 µg/kg in sample SB106A composed of sinter and slag materials.
- Dibenzo(a,h)anthracene was not detected in any Investigation Area 4 subsurface soil samples.

Soil boring SB106 is located off-site past the northern boundary of OU2.

Indeno(1,2,3-cd)pyrene

The RRSL and IRSL for indeno(1,2,3-cd)pyrene are 150 and 2,100 µg/kg, respectively.

- One surface soil sample result (4 percent) exceeded the RRSL. No surface soil sample results exceeded the IRSL.
- No subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected surface soil indeno(1,2,3-cd)pyrene concentration was 720 µg/kg in sample SB106A composed of sinter and slag materials.
- The maximum detected subsurface soil indeno(1,2,3-cd)pyrene concentration was 40 µg/kg in sample SB104B collected from 8 to 10 ft bgs composed of shale and limestone materials.

Soil boring SB106 is located off-site past the northern boundary of OU2.

Within Investigation Area 4, a total of 54 soil samples were analyzed for SVOCs, of which 7 percent exceeded the RRSL. Most SVOC exceedances were detected in samples of native materials and slag, sinter, and fill materials. No surface or subsurface soil results exceeded the IRSLs for SVOCs within Investigation Area 4. Generally, SVOC concentrations were higher in surface soil than in subsurface soil, and the highest concentrations generally were located in soil boring SB106 located off-site past the northern boundary of OU2 and in SB104 along the former ICRR railroad tracks. SVOCs in surface and subsurface soils have been adequately defined in Investigation Area 4.

PCBs

Of the 104 surface soil samples collected from Investigation Area 4, 27 were analyzed by the CLP laboratory for PCBs (Figure 4.2.2-10a). All 27 subsurface soil samples collected from Investigation Area 4 were analyzed by the CLP laboratory for PCBs (Figure 4.2.2-10b). Table 4.2.2-4a summarizes the detected PCB results for all the soil samples. Table S-13 in Appendix S-13 presents the full set of soil PCB results.

- No surface or subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.
- PCBs were not detected in any of the Investigation Area 4 surface or subsurface soil samples.

Therefore, PCBs in surface and subsurface soils are not a concern in Investigation Area 4.

Pesticides

Of the 104 surface soil samples collected from Investigation Area 4, 27 were analyzed by the CLP laboratory for pesticides (Figure 4.2.2-11a). All 27 subsurface soil samples collected from Investigation Area 4 were analyzed by the CLP laboratory for pesticides (Figure 4.2.2-11b). Table 4.2.2-5 summarizes the detected pesticide results for all the soil samples. Table S-14 in Appendix S-14 presents the full set of soil pesticide results.

- No surface or subsurface soil sample results (0 percent) exceeded the RRSL or IRSL.

Asbestos

Of the 104 surface soil samples collected from Investigation Area 4, 27 were analyzed by STAT Laboratories for asbestos (Figure 4.2.2-12). Of the 28 subsurface soil samples collected from Investigation Area 4, 1 was analyzed by STAT Laboratories for asbestos (Figure 4.2.2-12). Table 4.2.2-6 summarizes the asbestos results for all the soil samples. Table S-15 in Appendix S-15 presents the full set of soil asbestos results.

- No sample results (0 percent) were detected above the 0.25 percent detection limit.

TCLP Metals

No soil samples collected from Investigation Area 4 were analyzed for TCLP metals.

SPLP Metals

No soil samples collected from Investigation Area 4 were analyzed for SPLP metals.

Investigation Area 4 Summary

Soil sample results for Investigation Area 4 reveal that the following metals were detected at concentrations exceeding the RSLs: arsenic, cadmium, lead, zinc, cobalt, and manganese. Soil sample results for Investigation Area 4 reveal that SVOCs (a total of six compounds) were the only organic compounds detected in soil samples from Investigation Area 4 at concentrations exceeding the RSLs. The areas of highest soil impacts (analytes that exceeded the IRSLs) at Investigation Area 4 are summarized below.

The main area of arsenic-impacted surface soils is located in the southern portion of Investigation Area 4 with many smaller areas of impact in the northern portion (Figure 4.2.2-2c). There were only three small areas of arsenic-impacted subsurface soils in Investigation Area 4 (Figure 4.2.2-2d). Subsurface soil samples were not collected from many of the areas of arsenic-impacted surface soils due to the rough terrain that exists in Investigation Area 4. The main area of lead-impacted surface soil is located in the central portion of Investigation Area 4 bordering the northern portion of Investigation Area 3, with one smaller area of lead-impacted surface soil in the northern portion of Investigation Area 4 and two smaller areas of lead-impacted surface soil in the eastern portion of Investigation Area 4 (Figure 4.2.2-4c). Subsurface soil samples were not collected from all of the surface soil sampling locations, but the subsurface soil samples that were collected did not contain lead at concentrations exceeding either the RRSLs or IRSLS. The areas closest to the central portion of the former main industrial area and along the southern and southwestern borders of Investigation Area 4 exhibited the highest metals concentrations.

4.2.2.5 Investigation Area 5: Residential Area/Off-site Area

A total of 284 surface grab soil samples were collected from Investigation Area 5, Residential Area/Off-site Area (Figure 4.2.2-1b). The residential samples (264) were collected west, northwest, and southwest of the Matthiessen and Hegeler Zinc Company Site, and off-site (non-residential) surface soil grab samples (20) were collected east of the Site, along the eastern bank of the LVR. Of the 284 collected surface grab samples 156 were XRF-screened soil samples (24 residential surface grab samples from May 2010 were not XRF-screened), and 128 were submitted to the CLP laboratory for total metals analysis. As explained in [Section 4.2.2](#), metals results for the 128 CLP analyzed samples and the other 156 adjusted XRF-screened results are presented below. The surface soil total metals results for Investigation Area 5 are summarized below, followed by a summary of the Investigation Area 5 results.

Total Metals

All 284 surface soil samples collected from Investigation Area 5 were screened for lead and zinc using the XRF analyzer (with some samples screened for cadmium as explained in [Section 4.2.2](#)), and 128 of these samples also were submitted to the laboratory for total metals analysis. Table 4.2.2-9 presents all metals results. Because of the large number of analytical detections and concentrations exceeding the US EPA RRSL and IRSLS, results for the individual metal analytes are discussed below based on the number of RSL exceedances. Please note, the December 2009 RSLs were used for all metals except total chromium and thallium. Chromium and thallium results were compared to the April 2009 RSLs.

Arsenic

A total of 128 surface soil samples collected from Investigation Area 5 were analyzed by the CLP laboratory for arsenic (Figure 4.2.2-14a). The RRSL and IRSL for arsenic are 0.39 and 1.6 mg/kg, respectively. The BTV for arsenic in surface soils is 10.7 mg/kg. The BTV is above both the RSLs.

- All 128 soil sample results (100 percent) exceeded both the RRSL and IRSL. A total of 86 soil sample results (67 percent) exceeded the surface soil BTV.
- The maximum detected soil arsenic concentration was 75.5 mg/kg in sample 408015 collected east of the LVR.
- The maximum detected residential soil arsenic concentration was 51.2 mg/kg in sample JOLI_1522.

All soil samples exceeded the RRSL and IRSL but when compared to the BTV, 67 percent of the samples exceeded the BTV of 10.7 mg/kg. Arsenic exceeded the BTV in a large portion of Investigation Area 5 and the highest concentration of arsenic in the residential area was about 650 ft west of the Matthiessen and Hegeler Zinc Company Site boundary. Figure 4.2.2-14b shows the extent of arsenic-impacted soil.

Cadmium

A total of 128 surface soil samples collected from Investigation Area 5 were analyzed by the CLP laboratory for cadmium (Figure 4.2.2-15a). The RRSL and IRSL for cadmium are 70 and 800 mg/kg, respectively. The BTV for cadmium in surface soils is 7.1 mg/kg. The surface BTV is below the RSLs.

- A total of 14 soil sample results (11 percent) exceeded the RRSL. No soil sample results exceeded the IRSL.
- The maximum detected soil cadmium concentration was 467 mg/kg in sample 408016 collected east of the LVR.
- The maximum detected residential soil cadmium concentration was 120 mg/kg in sample MH2_S005_FY_0-6.

Soil sample 408019 was collected from east of the LVR in the northern portion of the sampled area, and sample MH2_S005_FY_0-6 was collected from a residential front yard located approximately 200 ft west of the western boundary of OU2. Cadmium concentrations exceeded the RRSL at residences to up to 610 ft west of the western boundary of OU2. East of the LVR, results for samples collected from in the

northern portion of the sampled area exceeded the RRSL. Figure 4.2.2-15b shows the extent of cadmium-impacted soil.

Lead

All 284 soil samples collected from Investigation Area 5 were analyzed by the CLP laboratory or screened using the XRF analyzer for lead (Figure 4.2.2-16a). The RRSL and IRSL for lead are 400 and 800 mg/kg, respectively. The BTV for lead in surface soils is 103 mg/kg. The surface BTV is below the RSLs.

- A total of 64 soil sample results (23 percent) and 12 soil sample results (4 percent) exceeded the RRSL and IRSL, respectively.
- The maximum detected soil lead concentration was 3,220 mg/kg in sample MHS-112-BY-1.

Soil sample MHS-112-BY-1 was collected from a residential back yard approximately 2,000 ft southwest of the OU1 boundary. Residential and IRSL exceedances for lead were prevalent in samples collected west and southwest of the OU1 and OU2 boundary. Figure 4.2.2-16b shows the extent of lead-impacted soil.

Mercury

A total of 128 soil samples collected from Investigation Area 5 were analyzed by the CLP laboratory for mercury. A figure showing the mercury results was not prepared because no soil sample results for mercury exceeded the RRSL or IRSL. The RRSL and IRSL for mercury are 5.6 and 34 mg/kg, respectively. The BTV for mercury in surface soils is 1.32 mg/kg. The surface BTV is below the RSLs.

- No soil sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected soil mercury concentration was 3.91 mg/kg in sample MH2_S024_FY_6-12.

Zinc

All 284 soil samples collected from Investigation Area 5 were analyzed by the CLP laboratory or screened using the XRF analyzer for zinc (Figure 4.2.2-17a). The RRSL and IRSL for zinc are 23,000 and 310,000 mg/kg, respectively. The BTV for zinc in surface soils is 1,310 mg/kg. The surface BTV is below the RSLs.

- Four soil sample results (1 percent) exceeded the RRSL. No soil sample results exceeded the IRSL.
- The maximum detected soil zinc concentration was 51,500 mg/kg in sample 408016 collected east of the LVR.

Soil sample 408016 was collected from the northern portion of the area sampled east of the LVR. None of the results for soil samples collected from the residential properties exceeded the RRSL or IRSL for zinc. Figure 4.2.2-17b shows the extent of zinc-impacted soil.

Cobalt

A total of 128 soil samples collected from Investigation Area 5 were analyzed by the CLP laboratory for cobalt (Figure 4.2.2-18a). The RRSL and IRSL for cobalt are 23 and 300 mg/kg, respectively. The BTV for cobalt in surface soils is 12.9 mg/kg. The surface BTV is below the RSLs.

- One soil sample result (1 percent) exceeded the RRSL. No soil sample results exceeded the IRSL.
- The maximum detected soil cobalt concentration was 28.7 mg/kg in sample GOODD_650 (the duplicate sample of GOOD_650).

Soil sample GOODD_650 was collected from a residential side yard located one half mile west of the southern boundary of OU1. None of the results for soil samples collected from the residential properties or off-site locations exceeded the RRSL or IRSL for cobalt. Figure 4.2.2-18b shows the extent of cobalt-impacted soil.

Manganese

A total of 128 soil samples collected from Investigation Area 5 were analyzed by the CLP laboratory for manganese (Figure 4.2.2-18a). The RRSL and IRSL for manganese are 1,800 and 23,000 mg/kg, respectively. The BTV for manganese in surface soils is 1,527 mg/kg. The surface BTV is below the RSLs.

- A total of 11 soil sample results (9 percent) exceeded the RRSL. No soil sample results exceeded the IRSL.
- The maximum detected soil manganese concentration was 4,410 mg/kg in sample GOODD_650 (the duplicate sample of GOOD_650).

Soil sample GOODD_650 was collected from a residential side yard located one half mile west of the southern boundary of OU1. RSSL exceedances for manganese were in samples collected almost adjacent to the southern OU1 boundary. In addition, results for soil samples collected from east of the LVR in the central and northern portions of the area sampled exceeded the RSSL. Figure 4.2.2-18b shows the extent of manganese-impacted soil.

Investigation Area 5 Summary

Soil sample results for Investigation Area 5 reveal that the following metals were detected at concentrations exceeding the RSLs: arsenic, cadmium, lead, zinc, cobalt, and manganese; though no distinct pattern in the results is evident. For the purposes of this RI the impact of metal contaminants of interest in the residential and off-site areas are delineated. Future additional investigation of the residential and off-site areas may be warranted prior to any remedial action implementation and potential risk determination for residents. The areas of highest soil impacts at Investigation Area 5 are summarized below.

Arsenic concentrations exceeded both the RSSL and IRSL in all residential and off-site areas of Investigation Area 5. Arsenic concentrations exceeded the BTV in the residential area of Investigation Area 5 up to 4,770 ft northwest of the Matthiessen and Hegeler Zinc Company Site (Figure 4.2.2-14b). In the off-site area of Investigation Area 5, arsenic concentrations exceeded the BTV throughout most of the off-site area except for a small area in the southern, central and northern portions of Investigation Area 5 (Figure 4.2.2-14b). Cadmium concentrations exceeded the RSSL in the residential area of Investigation Area 5 up to 650 ft west of the Matthiessen and Hegeler Zinc Company Site (Figure 4.2.2-15b). In the off-site area of Investigation Area 5, cadmium concentrations exceeded the RSSL from approximately 1,000 ft north of the southernmost sampling location almost to the northernmost sampling location (Figure 4.2.2-15b). The area of highest lead concentrations is located approximately 2,000 ft southwest of the Matthiessen and Hegeler Zinc Company Site, and most of the highest lead concentrations were detected in the southeastern portion of the Investigation Area 5 residential area (Figure 4.2.2-16b). Lead results for samples collected from the off-site area of Investigation Area 5 exceeded the IRSL in the central to northern portion of the off-site area sampled along the LVR. The area of highest zinc concentrations exceeding the RSSL is located in the northern portion of the off-site area of Investigation Area 5 (Figure 4.2.2-17b). No zinc results exceeded the RSSL in the residential area of Investigation Area 5. Cobalt concentrations exceeded only the RSSL in the off-site area of Investigation Area 5 in one sample, which was located southwest of OU1 in the residential area (Figure 4.2.2-18b). Manganese

concentrations exceeded only the RRS� in the off-site area of Investigation Area 5, mostly in the northern portion of the off-site area (Figure 4.2.2-18b).

4.2.3 OU2 Building Material Results

Building material samples were collected during both Phase I and Phase II field investigations. SulTRAC collected 60 samples of concrete, brick, stone, wood, and other building materials (such as mortar and ceramic piping). The samples were collected from recognizable buildings and building structures in Investigation Areas 1 through 3 where associated historical activities may have been sources of contamination. Sample analytical results will be used to evaluate future disposal options, including the on-site placement of building materials as fill. Figure 4.2.3-1 shows the building material sampling locations. SulTRAC conducted the Phase I investigation in Summer 2007 and collected 10 building material samples on August 9 and 16, 2007. SulTRAC conducted the Phase II investigation between July 21 and 25, 2008, and collected 50 building material samples. All building material samples were collected as surface grab samples and analyzed for total metals, cyanide, VOCs (Phase II wood samples only), SVOCs, PCBs, pesticides, and asbestos. Of the 60 total samples, 5 also were analyzed for TCLP metals.

The samples were analyzed using the US EPA methods listed in Table 2.2.1-3 and in the Phase I and II SAPs (SulTRAC 2007 and 2008a). QC samples (field duplicate, MS, and MS/MSD samples) also were collected for building materials as described in the QAPP (SulTRAC 2008d). All building material sample identification numbers have the prefix “BM” before the three-digit sampling location number. Phase II samples are further classified by the following building material types: concrete (C), brick (K), stone (T), wood (W), or other (Z), and by a two-digit number indicating the year the sample was collected.

Tables 4.2.3-1 through 4.2.3-7 present the detected metals, VOC, SVOC, PCB, pesticides, asbestos, and TCLP metals analytical results, respectively. Because the building materials may be used on-site in the future and the materials frequently are comingled with soil material, the building material results were compared to the US EPA RRS� and IRS� for all analytes except asbestos and TCLP metals. The asbestos results are discussed as either detected or not detected. TCLP metals results were compared to the 40 CFR §261.24 regulatory levels. The December 2009 RSLs were used for all metals except total chromium and thallium. Chromium and thallium results were compared to the April 2009 RSLs.

The following sections discuss building material analytical results for Investigation Areas 1 through 3.

4.2.3.1 Investigation Area 1: Building 100

Three building material samples were collected from Investigation Area 1, Building 100. Building 100 is an intact brick building along the western edge of OU2. Samples were collected from the outer wall of Building 100 and from former buildings immediately east of Building 100 (Figure 4.2.3-1). The building material samples from Investigation Area 1 consisted of brick and concrete. The building material metals and cyanide, VOC, SVOC, PCB, pesticides, asbestos, and TCLP metals results for Investigation Area 1 are summarized below, followed by a summary of the Investigation Area 1 results.

Metals and Cyanide

All three building material samples collected from Investigation Area 1 were analyzed for total metals and cyanide. Table 4.2.3-1 summarizes the detected metals results. Appendix S-21 presents the full set of building material metals results. Analytical results are discussed for six individual analytes and are discussed below: arsenic, cadmium, lead, mercury, and zinc, and cyanide. In addition, analytical results for other analytes detected also are discussed under a general category called “other metals.” Because of the large number of analytical detections and concentrations exceeding the US EPA RRS� and IRS�, results for the individual metal analytes are discussed below based on the number of RSL exceedances.

Arsenic

All three building material samples were analyzed for arsenic (Figure 4.2.3-2). The RRS� and IRS� for arsenic are 0.39 and 1.6 mg/kg, respectively.

- All three sample results (100 percent) exceeded the RRS� and IRS�.
- The maximum detected arsenic concentration was 6.9 mg/kg in sample BM020K-08, a brick sample collected from the outer sidewall of Building 100.

Cadmium

All three building material samples were analyzed for cadmium (Figure 4.2.3-3). The RRS� and IRS� for cadmium are 70 and 800 mg/kg, respectively.

- None of the three sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected cadmium concentration was 13.3 mg/kg in sample BM021C-08, a concrete sample collected from the collapsed building section east of Building 100.

Lead

All three building material samples collected from Investigation Area 1 were analyzed for lead (Figure 4.2.3-4). The RRS� and IRS� for lead are 400 and 800 mg/kg, respectively.

- None of three sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected lead concentration was 10.3 mg/kg in sample BM022K-08, a brick sample collected from the collapsed building section east of Building 100.

Mercury

All three building material samples collected from Investigation Area 1 were analyzed for mercury (Figure 4.2.3-5). The RRS� and IRS� for mercury are 5.6 and 34 mg/kg, respectively.

- None of three sample results (0 percent of sample results) exceeded the RRS� or IRS�.
- The maximum detected mercury concentration was 0.061 mg/kg in sample BM020K-08, a brick sample collected from the outer sidewall of Building 100.

Zinc

All three building material samples collected from Investigation Area 1 were analyzed for zinc (Figure 4.2.3-6). The RRS� and IRS� for zinc are 23,000 and 310,000 mg/kg, respectively.

- None of three sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected zinc concentration was 1,480 mg/kg in sample BM020K-08, a brick sample collected from the outer sidewall of Building 100.

Other Metals

“Other metals” are a secondary group comprising metals detected more often than not in the building material samples. However, the spatial extents of these detected metals are not as great or the metal is not as potentially harmful as the metals individually discussed above (arsenic, cadmium, lead, mercury, and zinc). “Other metals” does not include the metals individually discussed above or the nutrient metals that do not have exceedance criteria (calcium, magnesium, potassium, and sodium). The secondary group of metals includes aluminum, antimony, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, thallium, and vanadium. Iron results are discussed only when results exceeded the IRS�.

All three Investigation Area 1 building material samples collected were analyzed for other metals (Figure 4.2.3-7). Table 4.2.3-1 lists the RRS� and IRS� for each of the other metals.

None of three sample results (0 percent) exceeded the RRS�s or IRS�s.

Cyanide

All three building material samples collected from Investigation Area 1 were analyzed for cyanide. The RRS� and IRS� for cyanide are 1,600 and 20,000 mg/kg, respectively.

- None of the three sample results (0 percent) exceeded the RRS� or IRS�.
- Cyanide was not detected in any of the samples at a detection limit of 2.6 mg/kg.

VOCs

According to the Phase II SAP, only building material samples composed of wood or those materials that exhibited staining were to be submitted for VOC analysis (SulTRAC 2008a) during the Phase II investigation. Investigation Area 1 building material samples collected during the Phase II investigation consisted of unstained brick and concrete only. Therefore, no Phase II building material samples from Investigation Area 1 were submitted for VOC analysis. Appendix S-22 includes the complete VOC results for all the building material samples.

SVOCs

All three building material samples collected from Investigation Area 1 were analyzed for SVOCs (Figure 4.2.3-8). Table 4.2.3-3 summarizes the detected SVOC results for all the building material samples. Appendix S-23 presents the full set of building material SVOC results.

- None of the three sample results (0 percent) exceeded the RRS� or IRS�.
- SVOCs were not detected in any of the Investigation Area 1 building material samples.

PCBs

All three building material samples collected from Investigation Area 1 were analyzed for PCBs (Figure 4.2.3-9). Table 4.2.3-4 summarizes the detected PCB results for all the building material samples and the RRS� for each PCB congener. Appendix S-24 presents the full set of building material PCB results. The RRS� and IRS� for PCBs (Aroclor-1254 and Aroclor-1260) are 220 and 740 µg/kg, respectively.

- Aroclor-1254 and Aroclor-1260 were detected in the Investigation Area 1 building material samples.
- One of three sample results (33 percent) exceeded the RRS� for Aroclor-1260.
- None of the sample results (0 percent) exceeded the IRSLS for any Aroclor.
- The maximum detected PCB concentration was 700 µg/kg in sample BM020K-08, a brick sample collected from the outer sidewall of Building 100.

Pesticides

All three building material samples collected from Investigation Area 1 were analyzed for pesticides (Figure 4.2.3-9). Table 4.2.3-5 summarizes the detected pesticide results for all the building material samples and the RSL for each pesticide. Appendix S-25 presents the full set of building material pesticide results.

- None of three sample results (0 percent) exceeded the RRS� or IRS�.

Asbestos

All three building material samples collected from Investigation Area 1 were analyzed for asbestos (Figure 4.2.3-10). Table 4.2.3-6 summarizes the asbestos results for all the building material samples. Appendix S-26 presents the full set of building material asbestos results.

- None of the samples tested positive for asbestos at a detection limit of 0.25 percent.

TCLP Metals

No building material samples collected from Investigation Area 1 were analyzed for TCLP metals.

Investigation Area 1 Summary

Building material sample results for Investigation Area 1 reveal that arsenic and PCBs were detected at concentrations exceeding the RSLs.

4.2.3.2 Investigation Area 2: Rolling Mill

Five building material samples were collected in Investigation Area 2, Rolling Mill. The building material samples from Investigation Area 2 consisted of brick, concrete, and other materials. The building material metals and cyanide, VOC, SVOC, PCB, pesticides, asbestos, and TCLP metals results

for Investigation Area 2 are summarized below, followed by a summary of the Investigation Area 2 results.

Metals and Cyanide

All five building material samples collected from Investigation Area 2 were analyzed for total metals and cyanide. Table 4.2.3-1 summarizes the detected metals results. Analytical results are discussed for six individual analytes and are discussed below: arsenic, cadmium, lead, mercury, and zinc, and cyanide. In addition, analytical results for other analytes detected also are discussed under a general category called “other metals.” Because of the large number of analytical detections and concentrations exceeding the US EPA RRS� and IRS�, results for the individual metal analytes are discussed below based on the number of RSL exceedances.

Arsenic

All five building material samples collected from Investigation Area 2 were analyzed for arsenic (Figure 4.2.3-2). The RRS� and IRS� for arsenic are 0.39 and 1.6 mg/kg, respectively.

- All five sample results (100 percent) exceeded the RRS�.
- Three sample results (60 percent) exceeded the IRS�.
- The maximum detected arsenic concentration was 6.4 mg/kg in sample BM049K-0, a brick sample from the front office building next to the Rolling Mill building.

Cadmium

All five building material samples collected from Investigation Area 2 were analyzed for cadmium (Figure 4.2.3-3). The RRS� and IRS� for cadmium are 70 and 800 mg/kg, respectively.

- None of five sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected cadmium concentration was 9.1 mg/kg in sample BM047Z-08, a building material sample collected from the north side of the Rolling Mill building.

Lead

All five building material samples collected from Investigation Area 2 were analyzed for lead (Figure 4.2.3-4). The RRS� and IRS� for lead are 400 and 800 mg/kg, respectively.

- None of five sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected lead concentration was 18.6 mg/kg in sample BM047Z-08, a building material sample collected from the north side of the Rolling Mill building.

Mercury

All five building material samples collected from Investigation Area 2 were analyzed for mercury (Figure 4.2.3-5). The RRS� and IRS� for mercury are 5.6 and 34 mg/kg, respectively.

- None of five sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected mercury concentration was 0.19 mg/kg in sample BM047Z-08, a building material sample collected from the north side of the Rolling Mill building.

Zinc

All five building material samples collected from Investigation Area 2 were analyzed for zinc (Figure 4.2.3-6). The RRS� and IRS� for zinc are 23,000 and 310,000 mg/kg, respectively.

One sample result (20 percent) exceeded the RRS�.

- None of the five sample results (0 percent) exceeded the IRS�.
- The maximum detected zinc concentration was 52,200 mg/kg in sample BM001, a concrete sample collected from the northwest corner of the Rolling Mill building.

Other Metals

“Other metals” are a secondary group comprising metals detected more often than not in the building material samples. However, the spatial extents of these detected metals are not as great or the metal is not as potentially harmful as the metals individually discussed above (arsenic, cadmium, lead, mercury, and zinc). “Other metals” does not include the metals individually discussed above or the nutrient metals that do not have exceedance criteria (calcium, magnesium, potassium, and sodium). The secondary group of metals includes aluminum, antimony, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, thallium, and vanadium. Iron results are discussed only when results exceeded the IRS�.

All five Investigation Area 2 building material samples collected were analyzed for other metals (Figure 4.2.3-7). Table 4.2.3-1 lists the RRS� and IRS� for each of the other metals.

None of five sample results (0 percent) exceeded the RRSLs or IRSLs.

Cyanide

All five building material samples collected from Investigation Area 2 were analyzed for cyanide. The RRSL and IRSL for cyanide are 1,600 and 20,000 mg/kg, respectively.

- None of five sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected cyanide concentration was 1.3 mg/kg in sample BM048C-08, a concrete sample collected from the northwest corner of the Rolling Mill building.

VOCs

According to the Phase II SAP, only building material samples composed of wood or those materials that exhibited staining were to be submitted for VOC analysis (SulTRAC 2008a) during the Phase II investigation. One of the five building material samples collected from Investigation Area 2 during Phase II was analyzed for VOCs. Table 4.2.3-2 summarizes the detected VOC results for all the building material samples. Appendix S-22 includes the complete VOC results for all the building material samples.

- No results for the one sample analyzed for VOCs (0 percent) exceeded the RRSL or IRSL.

SVOCs

All five building material samples collected from Investigation Area 2 were analyzed for SVOCs (Figure 4.2.3-8). Table 4.2.3-3 summarizes the detected SVOC results for all the building material samples. Appendix S-23 includes the complete SVOC results for all the building material samples.

- None of five sample results (0 percent) exceeded the RRSL or IRSL.

PCBs

All five building materials samples collected from Investigation Area 2 were analyzed for PCBs (Figure 4.2.3-9). Table 4.2.3-4 summarizes the detected PCB results for all the building material samples and the RSL for each PCB congener.

- PCBs were not detected in any of the samples at concentrations exceeding the detection limit of 32 µg/kg.

Pesticides

All five building material samples collected from Investigation Area 2 were analyzed for pesticides (Figure 4.2.3-9). Table 4.2.3-5 summarizes the detected pesticide results for all the building material samples and the RSL for each pesticide. Appendix S-25 presents the full set of building material pesticide results.

- None of five sample results (0 percent) exceeded the RRSL or IRSL.

Asbestos

All five building material samples collected from Investigation Area 2 were analyzed for asbestos (Figure 4.2.3-10). Table 4.2.3-6 summarizes the asbestos results for all the building material samples. Appendix S-26 presents the full set of building material asbestos results.

- None of the samples tested positive for asbestos at a detection limit of 0.25 percent.

TCLP Metals

One building material sample from Investigation Area 2 was analyzed for TCLP metals, sample BM049K-08. Table 4.2.3-7 summarizes the TCLP metals results for all the building material samples. Appendix S-27 presents the full set of building material TCLP metals results.

- Sample BM049K-08 contained multiple compounds, but no detected concentrations exceeded the TCLP regulatory levels for establishing toxicity.

Investigation Area 2 Summary

Building material sample results for Investigation Area 2 reveal that arsenic, and zinc were detected at concentrations exceeding the RSLs.

4.2.3.3 Investigation Area 3: Former Main Industrial Area

Fifty-two building material samples (excluding field duplicates) were collected from Investigation Area 3, Former Main Industrial Area. Figures 4.2.3-1 through 4.2.3-10 and Tables 4.2.3-1 through 4.2.3-7 show both the original and duplicate sample results. The building material samples from Investigation Area 3 consisted of brick, concrete, wood, stone, and other materials. The building materials metals and cyanide,

VOC, SVOC, PCB, pesticides, asbestos, and TCLP metals results for Investigation Area 3 are summarized below, followed by a summary of the Investigation Area 3 results.

Metals and Cyanide

All 52 building material samples collected from Investigation Area 3 were analyzed for total metals and cyanide. Table 4.2.3-1 summarizes the detected metals results. Appendix S-21 presents the full set of building material metals results. Analytical results are discussed for six individual analytes and are discussed below: arsenic, cadmium, lead, mercury, and zinc, and cyanide. In addition, analytical results for other analytes detected also are discussed under a general category called “other metals.” Because of the large number of analytical detections and concentrations exceeding the US EPA RRS� and IRS�, results for the individual metal analytes are discussed below based on the number of RSL exceedances.

Arsenic

All 52 building material samples collected from Investigation Area 3 were analyzed for arsenic (Figure 4.2.3-2). The RRS� and IRS� for arsenic are 0.39 and 1.6 mg/kg, respectively.

- Forty-seven sample results (90 percent) exceeded the RRS�.
- Forty sample results (77 percent) exceeded the RRS� and IRS�.
- The maximum detected arsenic concentration was 136 mg/kg in sample BM004, a brick sample collected from the former kilns.

Cadmium

All 52 building material samples collected from Investigation Area 3 were analyzed for cadmium (Figure 4.2.3-3). The RRS� and IRS� for cadmium are 70 and 800 mg/kg, respectively.

- Ten sample results (19 percent) exceeded the RRS�.
- None of the sample results (0 percent) exceeded the IRS�.
- The maximum detected cadmium concentration was 737 mg/kg in sample BM004, a brick sample collected from the former kilns.

Lead

All 52 building material samples collected from Investigation Area 3 were analyzed for lead (Figure 4.2.3-4). The RRS� and IRS� for lead are 400 and 800 mg/kg, respectively.

- Twelve sample results (25 percent) exceeded the RRSL.
- Seven sample results (13 percent) exceeded the IRSL.
- The maximum detected lead concentration was 4,210 mg/kg in sample BM008, a building material sample collected from the former kilns.

Mercury

All 52 building material samples collected from Investigation Area 3 were analyzed for mercury (Figure 4.2.3-5). The RRSL and IRSL for mercury are 5.6 and 34 mg/kg, respectively.

- Six sample results (12 percent) exceeded the RRSL.
- Three sample results (6 percent) exceeded the IRSL.
- The maximum detected mercury concentration was 105 mg/kg in sample BM051C-08, a concrete sample collected from the former kilns.

Zinc

All 52 building material samples collected from Investigation Area 3 were analyzed for zinc (Figure 4.2.3-6). The RRSL and IRSL for zinc are 23,000 and 310,000 mg/kg, respectively.

- Six sample results (12 percent) exceeded the RRSL.
- None of the sample results (0 percent) exceeded the IRSL.
- The maximum detected zinc concentration was 227,000 mg/kg in sample BM004, a brick sample collected from the former kilns.

Other Metals

“Other metals” are a secondary group comprising metals detected more often than not in the building material samples. However, the spatial extents of these detected metals are not as great or the metal is not as potentially harmful as the metals individually discussed above (arsenic, cadmium, lead, mercury, and zinc). “Other metals” does not include the metals individually discussed above or the nutrient metals that do not have exceedance criteria (calcium, magnesium, potassium, and sodium). The secondary group of metals includes aluminum, antimony, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, thallium, and vanadium. Iron results are discussed only when results exceeded the IRSL.

All 52 building material samples collected from Investigation Area 3 were analyzed for other metals (Figure 4.2.3-7). Table 4.2.3-1 summarizes the detected other metals results for Investigation Area 3 and lists the RRSL and IRSL for each of the other metals. Investigation Area 3 building material sample results exceeded the RRSL or IRSL for the following compounds: antimony, cobalt, manganese, and nickel. RSLs and results for each metal are summarized below.

Antimony

The RRSL and IRSL for antimony are 31 and 410 mg/kg, respectively.

- Five sample results (10 percent) exceeded the RRSL.
- One sample result (2 percent) exceeded the IRSL.
- The maximum detected antimony concentration was 412 mg/kg in sample BM007, an unknown sample material collected from the System 5 building.

Chromium

The RRSL and IRSL for chromium are 280 and 1,400 mg/kg, respectively.

- One sample result (2 percent) exceeded the RRSL.
- None of the sample results (0 percent) exceeded the IRSL.
- The maximum detected chromium concentration was 788 mg/kg in sample BM002, a brick sample collected from the former kilns.

Cobalt

The RRSL and IRSL for cobalt are 23 and 300 mg/kg, respectively.

- One sample result (2 percent) exceeded the RRSL.
- No sample results (0 percent) exceeded the IRSL.
- The maximum detected cobalt concentration was 24.3 mg/kg in sample BM004, a brick sample collected from the former kilns.

Manganese

The RRSL and IRSL for manganese are 1,800 and 23,000 mg/kg, respectively.

- One sample result (2 percent) exceeded the RRSL.
- None of the sample results (0 percent) exceeded the IRSL.
- The maximum detected manganese concentration was 2,500 mg/kg in sample BM012T-08, a stone sample collected from the former pottery building.

Nickel

The RRSL and IRSL for nickel are 1,500 and 20,000 mg/kg, respectively.

- One sample result (2 percent) exceeded the RRSL.
- None of the sample results (0 percent) exceeded the IRSL.
- The maximum detected nickel concentration was 1,750 mg/kg in sample BM004, a brick sample collected from the former kilns.

Cyanide

All 52 building material samples collected from Investigation Area 3 were analyzed for cyanide. The RRSL and IRSL for cyanide are 1,600 and 20,000 mg/kg, respectively.

- None of the sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected cyanide concentration was 5.3 mg/kg in sample BM016C-08, a concrete sample collected from the Systems 1 and 2 building.

VOCs

According to the Phase II SAP, only building material samples composed of wood or those materials that exhibited staining were to be submitted for VOC analysis (SulTRAC 2008a). Of the 52 building material samples collected from Investigation Area 3, 14 were analyzed for VOCs. Table 4.2.3-2 summarizes the detected VOC results for all the building material samples. Appendix S-22 includes the complete VOC results for all the building material samples.

- None of the sample results (0 percent) exceeded the RRSL or IRSL.

SVOCs

All 52 building material samples collected from Investigation Area 3 were analyzed for SVOCs (Figure 4.2.3-8). Table 4.2.3-3 summarizes the detected SVOC results for Investigation Area 2. Investigation

Area 3 building material sample results exceeded the RRSL or IRSL for the following polynuclear aromatic hydrocarbon (PAH) compounds: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and naphthalene. The elevated PAH concentrations primarily were detected in wood building material samples. RSLs and results for each PAH are summarized below.

Benzo(a)anthracene

The RRSL and IRSL for benzo(a)anthracene are 150 and 2,100 µg/kg, respectively.

- Fourteen sample results (27 percent) exceeded the RRSL.
- Seven sample results (13 percent) exceeded the IRSL.
- The maximum detected benzo(a)anthracene concentration was 270,000 µg/kg in sample BM029W-08, a wood sample collected from the System 3 building.

Benzo(a)pyrene

The RRSL and IRSL for benzo(a)pyrene are 15 and 210 µg/kg, respectively.

- Nineteen sample results (37 percent) exceeded the RRSL.
- Twelve sample results (23 percent) exceeded the IRSL.
- The maximum detected benzo(a)pyrene concentration was 200,000 µg/kg in sample BM029W-08, a wood sample collected from the System 3 building.

Benzo(b)fluoranthene

The RRSL and IRSL for benzo(b)fluoranthene are 150 and 2,100 µg/kg, respectively.

- Fourteen sample results (27 percent) exceeded the RRSL.
- Six sample results (12 percent) exceeded the IRSL.
- The maximum detected benzo(b)fluoranthene concentration was 210,000 µg/kg in sample BM029W-08, a wood sample collected from the System 3 building.

Benzo(g,h,i)perylene

The RRSL and IRSL for benzo(g,h,i)perylene are 150 and 2,100 µg/kg, respectively.

- Eight sample results (15 percent) exceeded the RRSL.
- Four sample results (8 percent) exceeded the IRSL.
- The maximum detected benzo(g,h,i)perylene concentration was 51,000 µg/kg in sample BM029W-08, a wood sample collected from the System 3 building.

Benzo(k)fluoranthene

The RRSL and IRSL for benzo(k)fluoranthene are 1,500 and 21,000 µg/kg, respectively.

- Seven sample results (13 percent) exceeded the RRSL.
- Two sample results (4 percent) exceeded the IRSL.
- The maximum detected benzo(k)fluoranthene concentration was 70,000 µg/kg in sample BM029W-08, a wood sample collected from the System 3 building.

Chrysene

The RRSL and IRSL for chrysene are 15,000 and 210,000 µg/kg, respectively.

- Three sample results (6 percent) exceeded the RRSL.
- One sample result (2 percent) exceeded the IRSL.
- The maximum detected chrysene concentration was 210,000 µg/kg in sample BM029W-08, a wood sample collected from the System 3 building.

Dibenzo(a,h)anthracene

The RRSL and IRSL for dibenzo(a,h)anthracene are 15 and 210 µg/kg, respectively.

- Six sample results (12 percent) exceeded the RRSL.
- Four sample results (8 percent) exceeded the IRSL.
- The maximum detected dibenzo(a,h)anthracene concentration was 1,300 µg/kg in sample BM054C-08, a concrete sample collected from the former sulfuric acid tanks.

Indeno(1,2,3-cd)pyrene

The RRSL and IRSL for indeno(1,2,3-cd)pyrene are 150 and 2,100 µg/kg, respectively.

- Twelve sample results (23 percent) exceeded the RRSL.

- Five sample results (10 percent) exceeded the IRSL.
- The maximum detected indeno(1,2,3-cd)pyrene concentration was 78,000 µg/kg in sample BM029W-08, a wood sample collected from the System 3 building.

Naphthalene

The RREL and IRSL for naphthalene are 3,900 and 20,000 µg/kg, respectively.

- One sample result (2 percent) exceeded the RREL and IRSL.
- The maximum detected naphthalene sample result was 7,200 µg/kg in sample BM042W-08, a wood sample from a pile of building debris between the Rolling Mill building and Building 1943.

PCBs

All 52 building materials samples collected from Investigation Area 3 were analyzed for PCBs (Figure 4.2.3-9). Aroclor-1016, Aroclor-1254, and Aroclor-1260 were detected in the building materials samples, but results for Aroclor-1260 only exceeded the RRELs. Table 4.2.3-4 summarizes the detected PCB results for all the building material samples. The RREL and IRSL for Aroclor-1016 are 3,900 and 21,000 µg/kg, respectively. The RREL and IRSL for Aroclor-1254 and Aroclor-1260 are 220 and 740 µg/kg, respectively.

- Ten sample results (19 percent) exceeded the detection limit of 32 µg/kg.
- One sample result (2 percent) exceeded the RREL for Aroclor-1260.
- No sample results (0 percent) exceeded the IRSLs.
- The maximum detected Aroclor-1260 concentration was 460 µg/kg in sample BM006, an unknown sample material collected from the western edge of Investigation Area 3.

Pesticides

All 52 building material samples collected from Investigation Area 3 were analyzed for pesticides (Figure 4.2.3-9). Table 4.2.3-5 summarizes the detected pesticide results for all the building material samples and the RSL for each pesticide. Multiple pesticide compounds were detected in the Investigation Area 3 building material samples. Appendix S-25 presents the full set of building material pesticide results.

- One sample result (2 percent) exceeded the RREL and IRSL for beta-BHC.

- Sample BM042W-08 contained beta-BHC at a concentration of 1,500 µg/kg, which exceeds the RREL of 270 µg/kg and IRSR of 960 µg/kg.
- The maximum detected pesticide concentration was for beta-BHC in sample BM042W-08, a wood sample collected from a pile of building debris between the Rolling Mill building and Building 1943.

Asbestos

All 52 building material samples collected from Investigation Area 3 were analyzed for asbestos (Figure 4.2.3-10). Table 4.2.3-6 summarizes the asbestos results for all the building material samples. Appendix S-26 presents the full set of building material asbestos results.

- Five sample results (10 percent) tested positive for asbestos at a detection limit of 0.25 percent.
- Two of the five samples testing positive for asbestos likely were collected from building materials manufactured using asbestos (for example, as a flame retardant in fire brick).

TCLP Metals

Four building material samples collected from Investigation Area 3 were analyzed for TCLP metals, samples BM013Z-08, BM028C-08, BM042W-08, and BM059K-08. Table 4.2.3-7 summarizes the TCLP metals results for all the building material samples. Appendix S-27 presents the full set of building material TCLP metals results. Results are summarized below.

- All four samples contained multiple compounds at detectable concentrations, but no detected concentrations exceeded the TCLP regulatory levels for establishing toxicity.

Investigation Area 3 Summary

Building material sample results for Investigation Area 3 reveal that concentrations of the following exceeded the RSLs: metals (arsenic, cadmium, lead, mercury, zinc, antimony, chromium, cobalt, manganese, and nickel), PAHs (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenzo[a,h]anthracene, indeno[1,2,3-cd]pyrene, and naphthalene), Aroclor-1260, and beta-BHC. In addition, asbestos also was detected in building material samples collected from Investigation Area 3.

4.2.4 OU2 Pile Results

Pile samples were collected from aboveground debris piles during the Phase I field investigation. SulTRAC collected 55 samples from the piles which were all located within Investigation Areas 1 through 3. Numerous debris piles are scattered across OU2 and typically, the piles are no taller than 10 ft and are less than 30 ft in diameter. Sample analytical results will be used to evaluate future disposal options, including the on-site placement of pile material as fill. Figure 4.2.4-1 shows the pile sampling locations. SulTRAC conducted the Phase I investigation in Summer 2007 and collected 55 pile samples (excluding 4 duplicate samples) between July 18 and August 11, 2007. SulTRAC conducted the Phase II investigation between July 21 and 25, 2008. However, no pile samples were collected during the Phase II investigation. Pile samples all were collected as surface grab samples and analyzed for total metals, cyanide, VOCs, SVOCs, PCBs, pesticides, and asbestos.

The samples were analyzed using the US EPA methods listed in Table 2.2.1-3 and in the Phase I SAP (SulTRAC 2007). QC samples (field duplicate, MS, and MS/MSD samples) also were collected for pile samples as described in the QAPP (SulTRAC 2008b). All pile sample identification numbers have the prefix "P" before the three-digit sampling location number.

Tables 4.2.4-1 through 4.2.4-6 present the detected metals, VOC, SVOC, PCB, pesticides, and asbestos analytical results, respectively. Because the materials in the piles may be used on-site as fill in the future and the materials frequently are comingled with soil material, the pile results were compared to the US EPA RRSLs and IRSLs for all analytes except asbestos. The asbestos results are discussed as either detected or not detected. The December 2009 RSLs were used for all metals except total chromium and thallium. Chromium and thallium results were compared to the April 2009 RSLs. The following sections discuss pile analytical results for Investigation Areas 1 through 3.

4.2.4.1 Investigation Area 1: Building 100

Three pile samples were collected from Investigation Area 1, Building 100. Building 100 is an intact brick building along the western edge of OU2. Samples were collected from piles in the vicinity of Building 100. The pile metals and cyanide, VOC, SVOC, PCB, pesticides, and asbestos results for Investigation Area 1 are summarized below, followed by a summary of the Investigation Area 1 results.

Metals and Cyanide

All three pile samples collected from Investigation Area 1 were analyzed for total metals and cyanide. Table 4.2.4-1 summarizes the detected metals results. Appendix S-28 presents the full set of pile metals results. Analytical results exceeded the RSLs for the following six individual analyte groups: arsenic, cadmium, lead, mercury, zinc, and cyanide. In addition, analytical results for other analytes detected also are discussed under a general category called “other metals.” Because of the large number of analytical detections and concentrations exceeding the US EPA RRSL and IRSL, results for the individual metal analytes are discussed below based on the number of RSL exceedances.

Arsenic

All three pile samples were analyzed for arsenic (Figure 4.2.4-2). The RRSL and IRSL for arsenic are 0.39 and 1.6 mg/kg, respectively.

- All three sample results (100 percent) exceeded the RRSL and IRSL.
- The maximum detected arsenic concentration was 526 mg/kg in sample P039 collected from a debris pile south of Building 100 along the access road.

Cadmium

All three pile samples were analyzed for cadmium (Figure 4.2.4-3). The RRSL and IRSL for cadmium are 70 and 800 mg/kg, respectively.

- All three sample results (100 percent) exceeded the RRSL.
- One sample result (33 percent) exceeded the IRSL.
- The maximum detected cadmium concentration was 2,010 mg/kg in sample P039 collected from a debris pile south of Building 100 along the access road.

Lead

All three pile samples were analyzed for lead (Figure 4.2.4-4). The RRSL and IRSL for lead are 400 and 800 mg/kg, respectively.

- All three sample results (100 percent) exceeded the RRSL and IRSL.
- The maximum detected lead concentration was 3,250 mg/kg in sample P018 collected from a debris pile east of the former thaw house building (east of Building 100).

Mercury

All three pile samples collected were analyzed for mercury (Figure 4.2.4-5). The RRSL and IRSL for mercury are 5.6 and 34 mg/kg, respectively.

- None of the three sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected mercury concentration was 5.4 mg/kg in sample P018 collected from a debris pile east of the former thaw house building (east of Building 100).

Zinc

All three pile samples collected were analyzed for zinc (Figure 4.2.4-6). The RRSL and IRSL for zinc are 23,000 and 310,000 mg/kg, respectively.

- Two of three sample results (67 percent) exceeded the RRSL.
- None of the three sample results (0 percent) exceeded the IRSL.
- The maximum detected zinc concentration was 250,000 mg/kg in sample P039 collected from a debris pile south of Building 100 along the access road.

Other Metals

“Other metals” are a secondary group comprising metals detected more often than not in the pile samples. However, the spatial extents of these detected metals are not as great or the metal is not as potentially harmful as the metals individually discussed above (arsenic, cadmium, lead, mercury, and zinc). “Other metals” does not include the metals individually discussed above or the nutrient metals that do not have exceedance criteria (calcium, magnesium, potassium, and sodium). The secondary group of metals includes aluminum, antimony, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, thallium, and vanadium. Iron results are discussed only when results exceeded the IRSL.

All three pile samples collected from Investigation Area 1 were analyzed for other metals (Figure 4.2.4-7). Table 4.2.4-1 summarizes the detected other metals results for Investigation Area 1 and lists the RRSL and IRSL for each of the other metals. Investigation Area 1 pile sample results exceeded the RRSL or IRSL for the following compounds: antimony, cobalt, iron, manganese, and thallium. RSLs and results for each metal are summarized below.

Antimony

The RRSL and IRSL for antimony are 31 and 410 mg/kg, respectively.

- One sample result (33 percent) exceeded the RRSL.
- None of the sample results (0 percent) exceeded the IRSL.
- The maximum detected antimony concentration was 32.6 mg/kg in sample P039 collected from a debris pile south of Building 100 along the access road.

Cobalt

The RRSL and IRSL for cobalt are 23 and 300 mg/kg, respectively.

- One sample result (33 percent) exceeded the RRSL.
- None of the sample results (0 percent) exceeded the IRSL.
- The maximum detected cobalt concentration was 42.2 mg/kg in sample P051 collected from a debris pile east of Building 100.

Iron

The RRSL and IRSL for iron are 55,000 and 720,000 mg/kg, respectively.

- One sample result (33 percent) exceeded the RRSL.
- None of the sample results (0 percent) exceeded the IRSL.
- The maximum detected iron concentration was 71,500 mg/kg in sample P039 collected from a debris pile south of Building 100 along the access road.

Manganese

The RRSL and IRSL for manganese are 1,800 and 23,000 mg/kg, respectively.

- One sample result (33 percent) exceeded the RRSL and IRSL.
- The maximum detected manganese concentration was 51,900 mg/kg in sample P051 collected from a debris pile east of Building 100.

Thallium

The RRSL and IRSL for thallium are 5.1 and 66 mg/kg, respectively.

- One sample result (33 percent) exceeded the RRSL.
- None of the sample results (0 percent) exceeded the IRSL.
- The maximum detected thallium concentration was 8.4 mg/kg in sample P051 collected from a debris pile east of Building 100.

Cyanide

All three pile samples collected were analyzed for cyanide. The RRSL and IRSL for cyanide are 1,600 and 20,000 mg/kg, respectively.

- None of three sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected cyanide concentration was 0.32 mg/kg in sample P051 collected from a debris pile east of Building 100.

VOCs

All three pile samples collected from Investigation Area 1 were analyzed for VOCs. Table 4.2.4-2 summarizes the detected VOC results for all pile samples. Appendix S-29 presents the full set of pile VOC results.

- None of three sample results (0 percent) exceeded the RRSL or IRSL.
- VOCs were not detected in any of the Investigation Area 1 pile samples at concentrations exceeding the detection limit of 5.7 µg/kg.

SVOCs

All three pile samples collected from Investigation Area 1 were analyzed for SVOCs (Figure 4.2.4-8). Table 4.2.4-3 summarizes the detected SVOC results for all the pile samples. Appendix S-30 presents the full set of pile SVOC results. Investigation Area 1 pile sample results exceeded the RRSL or IRSL for the following PAH compounds: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. RSLs and results for each PAH are summarized below.

Benzo(a)anthracene

The RRSL and IRSL for benzo(a)anthracene are 150 and 2,100 µg/kg, respectively.

- Three sample results (100 percent) exceeded the RRS�.
- None of the three sample results (0 percent) exceeded the IRSŁ.
- The maximum detected benzo(a)anthracene concentration was 1,200 µg/kg in sample P018 collected from a debris pile east of the former thaw house building (east of Building 100).

Benzo(a)pyrene

The RRSŁ and IRSŁ for benzo(a)pyrene are 15 and 210 µg/kg, respectively.

- Three sample results (100 percent) exceeded the RRSŁ.
- Two sample results (67 percent) exceeded the IRSŁ.
- The maximum detected benzo(a)pyrene concentration was 550 µg/kg in sample P051 collected from a debris pile east of Building 100.

Benzo(b)fluoranthene

The RRSŁ and IRSŁ for benzo(b)fluoranthene are 150 and 2,100 µg/kg, respectively.

- Three sample results (100 percent) exceeded the RRSŁ.
- One sample result (33 percent) exceeded the IRSŁ.
- The maximum detected benzo(b)fluoranthene concentration was 2,300 µg/kg in sample P018 collected from a debris pile east of the former thaw house building (east of Building 100).

Benzo(g,h,i)perylene

The RRSŁ and IRSŁ for benzo(g,h,i)perylene are 150 and 2,100 µg/kg, respectively.

- Three sample results (100 percent) exceeded the RRSŁ.
- None of the three sample results (0 percent) exceeded the IRSŁ.
- The maximum detected benzo(g,h,i)perylene concentration was 370 µg/kg in sample P051 collected from a debris pile east of Building 100.

Benzo(k)fluoranthene

The RRSŁ and IRSŁ for benzo(k)fluoranthene are 1,500 and 21,000 µg/kg, respectively.

- One sample results (33 percent) exceeded the RRSŁ.

- None of the three sample results (0 percent) exceeded the IRSL.
- The maximum detected benzo(k)fluoranthene concentration was 2,000 µg/kg in sample P018 collected from a debris pile east of the former thaw house building (east of Building 100).

Dibenzo(a,h)anthracene

The RRS� and IRSL for dibenzo(a,h)anthracene are 15 and 210 µg/kg, respectively.

- Three sample results (100 percent) exceeded the RRS�.
- One sample result (33 percent) exceeded the IRSL.
- The maximum detected dibenzo(a,h)anthracene concentration was 220 µg/kg in sample P018 collected from a debris pile east of the former thaw house building (east of Building 100).

Indeno(1,2,3-cd)pyrene

The RRS� and IRSL for indeno(1,2,3-cd)pyrene are 150 and 2,100 µg/kg, respectively.

- Three sample results (100 percent) exceeded the RRS�.
- None of the three sample results (0 percent) exceeded the IRSL.
- The maximum detected indeno(1,2,3-cd)pyrene concentration was 480 µg/kg in sample P018 collected from a debris pile east of the former thaw house building (east of Building 100).

PCBs

All three pile samples collected from Investigation Area 1 were analyzed for PCBs (Figure 4.2.4-9). Table 4.2.4-4 summarizes the detected PCB results for all the pile samples and the RSL for each PCB congener. Appendix S-31 presents the full set of pile PCB results. The RRS� and IRSL for PCBs (Aroclor-1260) are 220 and 740 µg/kg, respectively.

- Aroclor-1260 was detected in the Investigation Area 1 pile samples.
- One of three sample results (33 percent) exceeded the RRS� and IRSL for Aroclor-1260.
- The maximum detected PCB concentration was 1,200 µg/kg in sample P051 collected from a debris pile east of Building 100.

Pesticides

All three pile samples collected from Investigation Area 1 were analyzed for pesticides (Figure 4.2.4-9). Table 4.2.4-5 summarizes the detected pesticide results for all the pile samples and the RSL for each pesticide. Appendix S-32 presents the full set of pile pesticide results.

- One sample result (33 percent) exceeded the RRSL for dieldrin.
- None of the three sample results (0 percent) exceeded the IRSL.
- The maximum detected dieldrin sample result was 43 µg/kg in sample P051 collected from a debris pile east of Building 100.

Asbestos

All three pile samples collected from Investigation Area 1 were analyzed for asbestos (Figure 4.2.4-10). Table 4.2.4-6 summarizes the asbestos results for all the pile samples. Appendix S-33 presents the full set of pile asbestos results.

- None of the samples tested positive for asbestos at a detection limit of 0.25 percent.

Investigation Area 1 Summary

Pile sample results for Investigation Area 1 reveal that metals (arsenic, cadmium, lead, zinc, antimony, cobalt, iron, manganese, and thallium), PAHs (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, dibenzo[a,h]anthracene, and indeno[1,2,3-cd]pyrene), Aroclor-1260, and dieldrin were detected at concentrations exceeding the RSLs.

4.2.4.2 Investigation Area 2: Rolling Mill

Four pile samples were collected in Investigation Area 2, Rolling Mill. The pile metals and cyanide, VOC, SVOC, PCB, pesticides, and asbestos results for Investigation Area 2 are summarized below, followed by a summary of the Investigation Area 2 results.

Metals and Cyanide

All four pile samples collected from Investigation Area 2 were analyzed for total metals and cyanide. Table 4.2.4-1 summarizes the detected metals results. Analytical results exceeded the RSL for the following six individual analyte groups and are discussed below: arsenic, cadmium, lead, mercury, zinc,

and cyanide. In addition, analytical results for other analytes detected also are discussed under a general category called “other metals.” Because of the large number of analytical detections and concentrations exceeding the US EPA RRSL and IRSL, results for the individual metal analytes are discussed below based on the number of RSL exceedances.

Arsenic

All four pile samples were analyzed for arsenic (Figure 4.2.4-2). The RRSL and IRSL for arsenic are 0.39 and 1.6 mg/kg, respectively.

- Three sample results (75 percent) exceeded the RRSL and IRSL.
- The maximum detected arsenic concentration was 16.9 mg/kg in sample P003S collected from a debris pile on the north side of the Rolling Mill building.

Cadmium

All four pile samples were analyzed for cadmium (Figure 4.2.4-3). The RRSL and IRSL for cadmium are 70 and 800 mg/kg, respectively.

- One sample result (25 percent) exceeded the RRSL.
- None of the four sample results (0 percent) exceeded the IRSL.
- The maximum detected cadmium concentration was 108 mg/kg in sample P003S collected from a debris pile on the north side of the Rolling Mill building.

Lead

All four pile samples were analyzed for lead (Figure 4.2.4-4). The RRSL and IRSL for lead are 400 and 800 mg/kg, respectively.

- One sample result (25 percent) exceeded the RRSL and IRSL.
- The maximum detected lead concentration was 1,120 mg/kg in sample P003S collected from a debris pile on the north side of the Rolling Mill building.

Mercury

All four pile samples were analyzed for mercury (Figure 4.2.4-5). The RRSL and IRSL for mercury are 5.6 and 34 mg/kg, respectively.

- None of four sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected mercury concentration was 0.45 mg/kg in sample P003S collected from a debris pile on the north side of the Rolling Mill building.

Zinc

All four pile samples were analyzed for zinc (Figure 4.2.4-6). The RRS� and IRS� for zinc are 23,000 and 310,000 mg/kg, respectively.

- None of four sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected zinc concentration was 17,600 mg/kg in sample P003S collected from a debris pile on the north side of the Rolling Mill building.

Other Metals

“Other metals” are a secondary group comprising metals detected more often than not in the pile samples. However, the spatial extents of these detected metals are not as great or the metal is not as potentially harmful as the metals individually discussed above (arsenic, cadmium, lead, mercury, and zinc). “Other metals” does not include the metals individually discussed above or the nutrient metals that do not have exceedance criteria (calcium, magnesium, potassium, and sodium). The secondary group of metals includes aluminum, antimony, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, thallium, and vanadium. Iron results are discussed only when results exceeded the IRS�.

All four pile samples collected from Investigation Area 2 were analyzed for other metals (Figure 4.2.4-7). Table 4.2.4-1 summarizes the detected other metals results for Investigation Area 2 and lists the RRS� and IRS� for each of the other metals. Investigation Area 2 pile sample results exceeded the RRS� or IRS� for the following compounds: copper, and iron. RSLs and results for each metal are summarized below.

Copper

The RRS� and IRS� for copper are 3,100 and 41,000 mg/kg, respectively.

- One sample result (25 percent) exceeded the RRS�.
- None of the sample results (0 percent) exceeded the IRS�.

- The maximum detected copper concentration was 12,500 mg/kg in sample P017 collected from a debris pile west of the Rolling Mill building.

Iron

The RRSL and IRSL for iron are 55,000 and 720,000 mg/kg, respectively.

- One sample result (25 percent) exceeded the RRSL.
- None of the sample results (0 percent) exceeded the IRSL.
- The maximum detected iron concentration was 71,200 mg/kg in sample P017 collected from a debris pile west of the Rolling Mill building.

Cyanide

All four pile samples were analyzed for cyanide. The RRSL and IRSL for cyanide are 1,600 and 20,000 mg/kg, respectively.

- None of four sample results (0 percent) exceeded the RRSL or IRSL.
- The maximum detected cyanide concentration was 105 mg/kg in sample P017 collected from a debris pile west of the Rolling Mill building.

VOCs

All four pile samples collected from Investigation Area 2 were analyzed for VOCs. Table 4.2.4-2 summarizes the detected VOC results for all the pile samples. Appendix S-29 presents the full set of VOC results.

- None of four sample results (0 percent) exceeded the RRSL or IRSL.

SVOCs

All four pile samples collected from Investigation Area 2 were analyzed for SVOCs (Figure 4.2.4-8). Table 4.2.4-3 summarizes the detected SVOC results for all the pile samples. Appendix S-30 includes the complete SVOC results for all the pile samples. Investigation Area 2 pile sample results exceeded the RRSL or IRSL for the following PAH compounds: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. RSLs and results for each PAH are summarized below.

Benzo(a)anthracene

The RRS� and IRS� for benzo(a)anthracene are 150 and 2,100 µg/kg, respectively.

- Three sample results (75 percent) exceeded the RRS�.
- One sample result (25 percent) exceeded the IRS�.
- The maximum detected benzo(a)anthracene concentration was 2,200 µg/kg in sample P017 collected from a debris pile west of the Rolling Mill building.

Benzo(a)pyrene

The RRS� and IRS� for benzo(a)pyrene are 15 and 210 µg/kg, respectively.

- Three sample results (75 percent) exceeded the RRS� and IRS�.
- The maximum detected benzo(a)pyrene concentration was 1,000 µg/kg in sample P003S collected from a debris pile on the north side of the Rolling Mill building.

Benzo(b)fluoranthene

The RRS� and IRS� for benzo(b)fluoranthene are 150 and 2,100 µg/kg, respectively.

- Three sample results (75 percent) exceeded the RRS�.
- One sample result (25 percent) exceeded the IRS�.
- The maximum detected benzo(b)fluoranthene concentration was 2,400 µg/kg in sample P017 collected from a debris pile west of the Rolling Mill building.

Benzo(g,h,i)perylene

The RRS� and IRS� for benzo(g,h,i)perylene are 150 and 2,100 µg/kg, respectively.

- Three sample results (75 percent) exceeded the RRS�.
- None of the four sample results (0 percent) exceeded the IRS�.
- The maximum detected benzo(g,h,i)perylene concentration was 810 µg/kg in sample P003S collected from a debris pile on the north side of the Rolling Mill building.

Dibenzo(a,h)anthracene

The RRS� and IRS� for dibenzo(a,h)anthracene are 15 and 210 µg/kg, respectively.

- Two sample results (50 percent) exceeded the RRS�.
- One sample result (25 percent) exceeded the IRS�.
- The maximum detected dibenzo(a,h)anthracene concentration was 270 µg/kg in sample P003S collected from a debris pile on the north side of the Rolling Mill building.

Indeno(1,2,3-cd)pyrene

The RRS� and IRS� for indeno(1,2,3-cd)pyrene are 150 and 2,100 µg/kg, respectively.

- Three sample results (75 percent) exceeded the RRS�.
- None of the four sample results (0 percent) exceeded the IRS�.
- The maximum detected indeno(1,2,3-cd)pyrene concentration was 950 µg/kg in sample P003S collected from a debris pile on the north side of the Rolling Mill building.

PCBs

All four pile samples collected from Investigation Area 2 were analyzed for PCBs (Figure 4.2.4-9). Table 4.2.4-4 summarizes the detected PCB results for all the pile samples and the RSL for each PCB congener. Appendix S-31 presents the full set of pile PCB results. The RRS� and IRS� for PCBs (Aroclor-1260 and Aroclor-1248) are 220 and 740 µg/kg, respectively.

- None of the four sample results (0 percent) exceeded the RRS� or IRS�.
- Aroclor-1248 and Aroclor-1260 were detected in the Investigation Area 2 pile samples.
- The maximum detected PCB concentration was 84 µg/kg of Aroclor-1260 in sample P055 collected from a debris pile in the southwest corner of OU2 between the Rolling Mill building and the road.

Pesticides

All four pile samples collected from Investigation Area 2 were analyzed for pesticides (Figure 4.2.4-9). Table 4.2.4-5 summarizes the detected pesticide results for all the pile samples and the RSL for each pesticide. Appendix S-32 presents the full set of pile pesticide results.

- None of four sample results (0 percent) exceeded the RRS� or IRS�.

Asbestos

All four pile samples collected from Investigation Area 2 were analyzed for asbestos (Figure 4.2.4-10). Table 4.2.4-6 summarizes the asbestos results for all the pile samples. Appendix S-33 presents the full set of pile asbestos results.

- None of the samples tested positive for asbestos at a detection limit of 0.25 percent.

Investigation Area 2 Summary

Pile sample results for Investigation Area 2 reveal that metals (arsenic, cadmium, lead, copper, and iron) and PAHs (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, dibenzo[a,h]anthracene, and indeno[1,2,3-cd]pyrene) were detected at concentrations exceeding the RSLs.

4.2.4.3 Investigation Area 3: Former Main Industrial Area

Forty-eight pile samples were collected from Investigation Area 3, Former Main Industrial Area. Figures 4.2.4-1 through 4.2.4-10 and Tables 4.2.4-1 through 4.2.4-6 show both the original and duplicate sample results. The pile metals and cyanide, VOC, SVOC, PCB, pesticides, and asbestos results for Investigation Area 3 are summarized below, followed by a summary of the Investigation Area 3 results.

Metals and Cyanide

All 48 pile samples collected from Investigation Area 3 were analyzed for total metals and cyanide. Table 4.2.4-1 summarizes the detected metals results. Appendix S-28 presents the full set of pile metals results. Analytical results are discussed for six individual analyte groups: arsenic, cadmium, lead, mercury, and zinc, and cyanide. In addition, analytical results for other analytes detected also are discussed under a general category called “other metals.” Because of the large number of analytical detections and concentrations exceeding the US EPA RRSL and IRSL, results for the individual metal analytes are discussed below based on the number of RSL exceedances.

Arsenic

All 48 pile samples were analyzed for arsenic (Figure 4.2.4-2). The RRSL and IRSL for arsenic are 0.39 and 1.6 mg/kg, respectively.

- Forty-six sample results (96 percent) exceeded the RRS� and IRS�.
- The maximum detected arsenic concentration was 555 mg/kg in sample P050 collected from a debris pile on the southern edge of the System 3 building in a former coke crushing area.

Cadmium

All 48 pile samples were analyzed for cadmium (Figure 4.2.4-3). The RRS� and IRS� for cadmium are 70 and 800 mg/kg, respectively.

- Thirty-four sample results (71 percent) exceeded the RRS�.
- Two sample results (4 percent) exceeded the IRS�.
- The maximum detected cadmium concentration was 7,350 mg/kg in sample P014S collected from a debris pile on the northern edge of the former main industrial area.

Lead

All 48 samples were analyzed for lead (Figure 4.2.4-4). The RRS� and IRS� for lead are 400 and 800 mg/kg, respectively.

- Forty-three sample results (90 percent) exceeded the RRS�.
- Forty-one sample results (85 percent) exceeded the IRS�.
- The maximum detected lead concentration was 51,900 mg/kg in sample P011S collected from a debris pile located at the northwest corner of the former System 5 building.

Mercury

All 48 pile samples were analyzed for mercury (Figure 4.2.4-5). The RRS� and IRS� for mercury are 5.6 and 34 mg/kg, respectively.

- Eight sample results (17 percent) exceeded the RRS�.
- Three sample results (6 percent) exceeded the IRS�.
- The maximum detected mercury concentration was 116 mg/kg in sample P045 collected from a debris pile on the south corner of the former System 5 building.

Zinc

All 48 pile samples were analyzed for zinc (Figure 4.2.4-6). The RRSL and IRSL for zinc are 23,000 and 310,000 mg/kg, respectively.

- Thirty-one sample results (65 percent) exceeded the RRSL.
- Two sample results (4 percent) exceeded the IRSL.
- The maximum detected zinc concentration was 408,000 mg/kg in sample P023 collected from a debris pile on the south corner of the former System 4 building.

Other Metals

“Other metals” are a secondary group comprising metals detected more often than not in the pile samples. However, the spatial extents of these detected metals are not as great or the metal is not as potentially harmful as the metals individually discussed above (arsenic, cadmium, lead, mercury, and zinc). “Other metals” does not include the metals individually discussed above or the nutrient metals that do not have exceedance criteria (calcium, magnesium, potassium, and sodium). The secondary group of metals includes aluminum, antimony, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, thallium, and vanadium. Iron results are discussed only when results exceeded the IRSL.

All 48 pile samples collected from Investigation Area 3 were analyzed for other metals (Figure 4.2.4-7). Table 4.2.4-1 summarizes the detected other metals results for Investigation Area 3 and lists the RRSL and IRSL for each of the other metals. Investigation Area 3 pile sample results exceeded the RRSL or IRSL for the following compounds: antimony, cobalt, copper, iron, manganese, nickel, and thallium. RSLs and results for each metal are summarized below.

Antimony

The RRSL and IRSL for antimony are 31 and 410 mg/kg, respectively.

- Eleven sample results (23 percent) exceeded the RRSL.
- One sample result (2 percent) exceeded the IRSL.
- The maximum detected antimony concentration was 1,040 mg/kg in sample P050 collected from a debris pile on the southern edge of the System 3 building in a former coke crushing area.

Cobalt

The RRS� and IRS� for cobalt are 23 and 300 mg/kg, respectively.

- Twelve sample result (25 percent) exceeded the RRS�.
- None of the sample results (0 percent) exceeded the IRS�.
- The maximum detected cobalt concentration was 258 mg/kg in sample P032 collected from a debris pile on the northeast edge of the former main industrial area.

Copper

The RRS� and IRS� for copper are 3,100 and 41,000 mg/kg, respectively.

- Three sample results (6 percent) exceeded the RRS�.
- None of the sample results (0 percent) exceeded the IRS�.
- The maximum detected copper concentration was 9,270 mg/kg in sample P050 collected from a debris pile on the southern edge of the System 3 building in a former coke crushing area.

Iron

The RRS� and IRS� for iron are 55,000 and 720,000 mg/kg, respectively.

- Twenty-two sample results (46 percent) exceeded the RRS�.
- None of the sample results (0 percent) exceeded the IRS�.
- The maximum detected iron concentration was 153,000 mg/kg in sample P014S collected from a debris pile on the northern edge of the former main industrial area.

Manganese

The RRS� and IRS� for manganese are 1,800 and 23,000 mg/kg, respectively.

- Seven sample results (15 percent) exceeded the RRS�.
- None of the sample results (0 percent) exceeded the IRS�.
- The maximum detected manganese concentration was 13,600 mg/kg in sample P032 collected from a debris pile on the northeast edge of the former main industrial area.

Nickel

The RRS� and IRS� for nickel are 1,500 and 20,000 mg/kg, respectively.

- One sample result (2 percent) exceeded the RRS�.
- None of the sample results (0 percent) exceeded the IRS�.
- The maximum detected nickel concentration was 2,840 mg/kg in sample P054 collected from a debris pile on the southeast corner of the former System 3 building.

Thallium

The RRS� and IRS� for nickel are 5.1 and 66 mg/kg, respectively.

- Two sample results (4 percent) exceeded the RRS�.
- None of the sample results (0 percent) exceeded the IRS�.
- The maximum detected thallium concentration was 5.7 mg/kg in sample P007S collected from a debris pile located on the eastern edge of the former main industrial area near the OU1 Slag Pile.

Cyanide

All pile samples collected from Investigation Area 3 were analyzed for cyanide. The RRS� and IRS� for cyanide are 1,600 and 20,000 mg/kg, respectively.

- None of the sample results (0 percent) exceeded the RRS� or IRS�.
- The maximum detected cyanide concentration was 11.2 mg/kg in sample P044 collected from a debris pile located near the western edge of the former kilns.

VOCs

All 48 pile samples collected from Investigation Area 3 were analyzed for VOCs. Table 4.2.4-2 summarizes the detected VOC results for all the pile samples. Appendix S-29 presents the full set of VOC results.

- None of 48 sample results (0 percent) exceeded the RRS� or IRS�.

SVOCs

All 48 pile samples collected from Investigation Area 3 were analyzed for SVOCs (Figure 4.2.4-8). Table 4.2.4-3 summarizes the detected SVOC results for all the pile samples. Appendix S-30 includes the complete SVOC results for all the pile samples. Investigation Area 2 pile sample results exceeded the RRSL or IRSL for the following PAH compounds: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. RSLs and results for each PAH are summarized below.

Benzo(a)anthracene

The RRSL and IRSL for benzo(a)anthracene are 150 and 2,100 µg/kg, respectively.

- Thirty-one sample results (65 percent) exceeded the RRSL.
- Seven sample results (15 percent) exceeded the IRSL.
- The maximum detected benzo(a)anthracene concentration was 22,000 µg/kg in sample P008S collected from a debris pile located at the northeast corner of the former furnace buildings.

Benzo(a)pyrene

The RRSL and IRSL for benzo(a)pyrene are 15 and 210 µg/kg, respectively.

- Thirty-nine sample results (81 percent) exceeded the RRSL.
- Twenty-six sample results (54 percent) exceeded the IRSL.
- The maximum detected benzo(a)pyrene concentration was 30,000 µg/kg in sample P008S collected from a debris pile located at the northeast corner of the former furnace buildings.

Benzo(b)fluoranthene

The RRSL and IRSL for benzo(b)fluoranthene are 150 and 2,100 µg/kg, respectively.

- Thirty-one sample results (65 percent) exceeded the RRSL.
- Ten sample results (21 percent) exceeded the IRSL.
- The maximum detected benzo(b)fluoranthene concentration was 27,000 µg/kg in sample P008S collected from a debris pile located at the northeast corner of the former furnace buildings.

Benzo(g,h,i)perylene

The RRS� and IRS� for benzo(g,h,i)perylene are 150 and 2,100 µg/kg, respectively.

- Twenty-five sample results (52 percent) exceeded the RRS�.
- Five sample results (10 percent) exceeded the IRS�.
- The maximum detected benzo(g,h,i)perylene concentration was 19,000 µg/kg in sample P008S collected from a debris pile located at the northeast corner of the former furnace buildings.

Benzo(k)fluoranthene

The RRS� and IRS� for benzo(k)fluoranthene are 1,500 and 21,000 µg/kg, respectively.

- Nine sample results (19 percent) exceeded the RRS�.
- One sample result (2 percent) exceeded the IRS�.
- The maximum detected benzo(k)fluoranthene concentration was 27,000 µg/kg in sample P008S collected from a debris pile located at the northeast corner of the former furnace buildings.

Chrysene

The RRS� and IRS� for chrysene are 15,000 and 210,000 µg/kg, respectively.

- Two sample results (4 percent) exceeded the RRS�.
- None of the sample results (0 percent) exceeded the IRS�.
- The maximum detected chrysene concentration was 24,000 µg/kg in sample P008S collected from a debris pile located at the northeast corner of the former furnace buildings.

Dibenzo(a,h)anthracene

The RRS� and IRS� for dibenzo(a,h)anthracene are 15 and 210 µg/kg, respectively.

- Twenty-six sample results (54 percent) exceeded the RRS�.
- Eleven sample results (23 percent) exceeded the IRS�.
- The maximum detected dibenzo(a,h)anthracene concentration was 4,900 µg/kg in sample P008S collected from a debris pile located at the northeast corner of the former furnace buildings.

Indeno(1,2,3-cd)pyrene

The RRS� and IRS� for indeno(1,2,3-cd)pyrene are 150 and 2,100 µg/kg, respectively.

- Twenty-six sample results (54 percent) exceeded the RRS�.
- Six sample results (13 percent) exceeded the IRS�.
- The maximum detected indeno(1,2,3-cd)pyrene concentration was 21,000 µg/kg in sample P008S collected from a debris pile located at the northeast corner of the former furnace buildings.

PCBs

All 48 pile samples collected from Investigation Area 3 were analyzed for PCBs (Figure 4.2.4-9). Table 4.2.4-4 summarizes the detected PCB results for all the pile samples and the RSL for each PCB congener. Appendix S-31 presents the full set of pile PCB results. The RRS� and IRS� for PCBs (Aroclor-1248, Aroclor-1254, and Aroclor-1260) are 220 and 740 µg/kg, respectively.

- Aroclor-1248, Aroclor-1254, and Aroclor-1260 were detected in the samples.
- Nine sample results (19 percent) exceeded the RRS� for one or more Aroclor compounds.
- Seven sample results (15 percent) exceeded the IRS� for one or more Aroclor compounds.
- The maximum detected PCB result was 8,100 µg/kg of Aroclor-1260 in sample P005S collected from a debris pile north of Building 1943 and east of the Rolling Mill building.

Pesticides

All 48 pile samples collected from Investigation Area 3 were analyzed for pesticides (Figure 4.2.4-9). Table 4.2.4-5 summarizes the detected pesticide results for all the pile samples and the RSL for each pesticide. Appendix S-32 presents the full set of pile pesticide results. Multiple pesticide compounds were detected in the Investigation Area 3 pile samples.

- Two of the sample results (4 percent) exceeded the RRS� and IRS� for dieldrin.
- The maximum detected pesticide concentration was 78 µg/kg of dieldrin in sample P046 collected from a debris pile between the former kilns and furnaces in the former main industrial area.

Asbestos

All 48 pile samples collected from Investigation Area 3 were analyzed for asbestos (Figure 4.2.4-10). Table 4.2.4-6 summarizes the asbestos results for all the pile samples. Appendix S-33 presents the full set of pile asbestos results.

- Eight sample results (17 percent) tested positive for asbestos at a detection limit of 0.25 percent.
- The maximum detected asbestos concentration was 6.5 percent asbestos in sample P040 collected from a debris pile southeast of Building 100 along the southwestern edge of the former main industrial area.

Investigation Area 3 Summary

Pile sample results for Investigation Area 3 reveal that metals (arsenic, cadmium, lead, mercury, zinc, antimony, cobalt, copper, iron, manganese, nickel, and thallium), PAHs (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenzo[a,h]anthracene, and indeno[1,2,3-cd]pyrene), PCBs (Aroclor-1248, Aroclor-1254, and Aroclor-1260), and dieldrin were detected at concentrations exceeding the RSLs. In addition, asbestos also was detected in pile samples collected from Investigation Area 3.

4.2.5 OU2 Groundwater Results

Groundwater MWs were installed during both Phase I and Phase II field investigations. Thirty-six groundwater MWs are currently installed at OU2. Groundwater sample analytical results will allow evaluation of current site conditions and potential remedial options. Figure 4.2.5-1 shows the MWs. SulTRAC conducted the Phase I investigation in Summer 2007 and installed 19 groundwater wells in August 2007. The wells installed during the Phase I event have been sampled up to eight times on a quarterly basis. However, data are not available for all wells from each round because of inadequate well recharge at some locations (Tables 4.2.5-1 and 2.2.2-3). SulTRAC conducted the Phase II investigation in July 2008 and installed 17 additional groundwater MWs. The MWs installed during the Phase II event have been sampled up to four times on a quarterly basis. However, data are not available for all wells from each round because of inadequate well recharge. Groundwater samples were collected as grab samples and analyzed for total and dissolved metals and cyanide, VOCs, SVOCs, PCBs, and pesticides. Table 4.2.5-1 summarizes the types of groundwater samples collected from each well during each sampling round.

The samples were analyzed using the US EPA methods listed in Table 2.2.1-3 and in the Phase I and II SAPs (SulTRAC 2007 and 2008a). QC samples (field duplicate, MS, and MS/MSD samples) also were collected for groundwater samples as described in the QAPP (SulTRAC 2008b). All groundwater sample identification numbers have the prefix “MW” before the two-digit well location number, followed by a four-digit number indicating the month and year the sample was collected.

The groundwater sample results were compared to the GWSV, which are the US EPA MCLs and US EPA Tap Water RSLs. Table 4.2.5-2 summarizes the GWSV exceedances in the groundwater samples collected from each MW. Table 4.2.5-2 lists all 36 MWs, and any analyte results that exceeded either the Tap Water RSL or MCL values for at least one round of sampling are marked for that well. Figure 4.2.5-2 shows the MCL and Tap Water RSL exceedances in the groundwater samples. Figures 4.2.5-3 through 4.2.5-27 show dissolved metal plume contours for WBZ1 and WBZ2 MWs based on December 2008 and June 2009 results. December 2008 and June 2009 results were chosen to represent dry and wet periods, respectively. Tables 4.2.5-3 through 4.2.5-7 present the detected metals, VOC, SVOC, PCB, and pesticides analytical results for each sample.

It should be noted that for certain analytes, the CLP CRQL for low-concentration groundwater analysis exceeded the groundwater GWSV. Table 5 in the “Year 1 Groundwater Sampling Review for Phase I MWs – Technical Memorandum” lists all detected analytes for which the CRQL exceeded the GWSV, including the range of the reported non-detect result values, and compares the results to the GWSVs (SulTRAC 2009).

In addition, six metal analytes had GWSVs less than the CRQLs: antimony, arsenic, beryllium, cadmium, cobalt, and thallium. Therefore, any non-detect results are reported at the CRQL concentration, which exceeds the GWSV. If the CRQL exceeded the GWSV, results listed as non-detect do not guarantee that the contaminant concentration is less than the GWSV. Each of these contaminants is discussed further in the respective sections below. The CRQLs used for the following rounds were for samples analyzed using ICP-AES under the CLP ILM 5.4 method: November 2007, March 2008, June 2008, September 2008, and December 2008. However, later samples from the March, June, and October 2009 rounds were analyzed using ICP-mass spectroscopy. The ICP-mass spectroscopy method provides CRQLs for antimony, arsenic, beryllium, cadmium, cobalt, and thallium all below their respective GWSVs. Although the ICP-mass spectroscopy analytical method was able to achieve CRQLs below the GWSVs, the statement of work (SOW) for this analytical method does not include analysis for aluminum, calcium, iron, magnesium, potassium, or sodium unless a SOW for a modified analysis is written. A modified analysis SOW was not written before the March 2009 sampling round. Therefore, groundwater samples

collected during the March 2009 sampling event were not analyzed for the subset of contaminants listed above. A modified analysis SOW was submitted for the June and October 2009 sampling events.

The following sections summarize the groundwater metals and cyanide, VOC, SVOC, PCB, and pesticides results for the WBZ1 and WBZ2 MWs. As previously described in [Section 3](#), WBZ1 is composed of unconsolidated Quaternary-aged native and fill materials and WBZ2 is the underlying Pennsylvanian-aged shale and limestone bedrock. Appendices S-34 through S-41 present the complete groundwater results and graphs for selected analytes and wells.

4.2.5.1 OU2 WBZ1 Monitoring Well Results

Twenty-three MWs are screened in WBZ1 (Figure 4.2.5-1). These MWs were sampled quarterly from the date of installation through October 2009. Groundwater metals and cyanide, VOC, SVOC, PCB, and pesticides results are summarized below for the WBZ1 MWs. Tables 4.2.5-1 and 4.2.5-2 summarize the compounds analyzed for in each well during each sampling round and summarize GWSV exceedances at each MW, respectively. Tables 4.2.5-3 through 4.2.5-7 summarize the detected results. Figure 4.2.5-2 shows all MWs with sample results that exceeded the GWSVs in each analyte group (metals, VOCs, SVOCs, PCBs, and pesticides).

Metals and Cyanide

All 23 WBZ1 MWs were sampled at least twice for metals and cyanide (Table 4.2.5-1). A total of 155 discrete groundwater samples, excluding field duplicates, were submitted for metals analysis. The higher value from the duplicate or original sample was used to evaluate the data discussed below.

Approximately half of the samples (100 of the 183 samples) were field filtered and represent dissolved metals concentrations. The remaining 83 of the 183 total samples were analyzed for total metals. Each WBZ1 MW has four filtered sample results except for MW08, MW26, and MW27. The dissolved and total metals sample results are discussed separately below. Table 4.2.5-3 summarizes the detected dissolved and total metals results.

Appendix S-34 presents the full set of metals in groundwater results. Figures 1 through 36 in Appendix S-35 show the dissolved and total metals results for arsenic, cadmium, lead, mercury, and zinc for each round of sampling at each MW. Figures 1 through 6 in Appendix S-36 show the dissolved and total metals results for cobalt, cyanide, iron, manganese, selenium, and thallium, respectively, at each MW where the metal analyte exceeded the GWSV for multiple sampling rounds. In the figures presented in Appendix S-35 and Appendix S-36, the CRQLs are shown for all results below the CRQLs. Results at or

below the CRQLs are shown in gray and detected results are shown in black. The higher of the sample duplicate or original sample result was used in the figures and in the discussion below. Because of the large number of analytical detections and concentrations exceeding the Tap Water RSLs and MCLs, results for the individual metal analytes are discussed below based on the number of Tap Water RSL and MCL exceedances.

Arsenic

All 23 WBZ1 MWs were sampled for arsenic. The Tap Water RSL and MCL for arsenic are 0.045 and 10 µg/L, respectively.

Total Arsenic

Below is a brief summary of groundwater sample results for total arsenic in WBZ1.

- Samples from 10 MWs (43 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from seven MWs (30 percent) exceeded the MCL for at least one round of sampling.
- Samples from three MWs (13 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected total arsenic concentration was 24.2 µg/L in a sample from MW MW07 collected in October 2007.

Dissolved Arsenic

Below is a brief summary of groundwater sample results for dissolved arsenic in WBZ1.

- Samples from 22 MWs (96 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from four MWs (17 percent) exceeded the MCL for at least one round of sampling.
- Samples from six MWs (26 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected dissolved arsenic concentration was 18.2 µg/L in a sample from MW MW15 collected in October 2009.

Generally, when arsenic concentrations exceeded the CRQL, the total and dissolved arsenic concentrations in the WBZ1 MWs were similar (Table 4.2.5-3 and Appendix S-35). Because the CRQL for arsenic frequently exceeded the Tap Water RSL and equaled the MCL, many of the arsenic results are listed as at or below the detection limit. When the CRQL exceeded the Tap Water RSL, the groundwater sample result could not be compared to the Tap Water RSL. When the samples were analyzed using the ICP-AES method, the arsenic CRQL was approximately 10 µg/L. When the samples were analyzed using the ICP-mass spectroscopy method, the arsenic CRQL was approximately 2 µg/L. The lower CRQL value for the ICP-mass spectroscopy method explains why more dissolved arsenic results exceeded the GWSV than total arsenic results. Turbidity does not appear to have affected arsenic concentrations.

Data for two MWs, MW04 and MW07, suggest a trend of decreasing arsenic concentrations (Appendix S-35). The detected total and dissolved arsenic concentrations steadily decreased from March 2009 through October 2009 and November 2007 through October 2009, respectively. Data for MWs MW10, MW12, and MW17 suggest that the total and dissolved arsenic concentrations are increasing at similar rates. Samples from seven MWs, MW15, MW21, MW24, MW25, MW29, MW31, and MW35, had steady arsenic concentrations that exceeded the CRQL and were at or exceeded the GWSV; however, no increasing or decreasing trend is evident.

Figures 4.2.5-3 and 4.2.5-4 show dissolved arsenic plumes for WBZ1 MWs based on December 2008 and June 2009 data, respectively. The figures both show dissolved arsenic concentrations in the center of the former main industrial area at OU2. Because the ICP-AES method was used in December 2008, the arsenic CRQL was 10 µg/L. Therefore, many sample results are reported as less than the CRQL. The ICP-mass spectroscopy method was used in June 2009, and more sample results are reported exceeding the CRQL and the GWSV.

Cadmium

All 23 WBZ1 MWs were sampled for cadmium. The Tap Water RSL and MCL values for cadmium are 18 and 5 µg/L, respectively.

Total Cadmium

Below is a brief summary of groundwater sample results for total cadmium in WBZ1.

- Samples from 14 MWs (61 percent) exceeded the Tap Water RSL for at least one round of sampling.

- Samples from 16 MWs (70 percent) exceeded the MCL for at least one round of sampling.
- Samples from 11 MWs (48 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected total cadmium concentration was 439 µg/L in a sample from MW MW31 collected in September 2008.

Dissolved Cadmium

Below is a brief summary of groundwater sample results for dissolved cadmium in WBZ1.

- Samples from 11 MWs (48 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from 15 MWs (65 percent) exceeded the MCL for at least one round of sampling.
- Samples from 11 MWs (48 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected dissolved cadmium concentration was 456 µg/L in a sample from MW MW11 collected in March 2009.

Generally, the detected total and dissolved cadmium concentrations in the WBZ1 MWs exceeded the MCL and Tap Water RSL (Table 4.2.5-3 and Appendix S-35). When cadmium concentrations exceeded the CRQL, the total and dissolved cadmium results were similar. Turbidity does not appear to have affected cadmium concentrations.

Data for one MW, MW17, suggest a trend of decreasing cadmium concentrations (Appendix S-35). The detected total and dissolved cadmium concentrations in MW17 decreased from November 2007 through October 2009. Additionally, data for MW MW17 show that the total and dissolved cadmium concentrations were very similar. Data for two MWs, MW11 and MW16, suggest a trend of increasing cadmium concentrations. Samples from seven MWs, MW04, MW06, MW07, MW09, MW24, MW25, and MW31, had steady cadmium concentrations that exceeded the CRQL and were at or exceeded the GWSVs; however, no increasing or decreasing trend is evident.

Figures 4.2.5-7 and 4.2.5-8 show dissolved cadmium plumes for WBZ1 MWs based on December 2008 and June 2009 data, respectively. The figures both show dissolved cadmium concentrations in the center of the former main industrial area at OU2. The highest dissolved cadmium concentrations are located in the central portion of OU2, and cadmium concentrations decrease to the north and south.

Lead

All 23 WBZ1 MWs were sampled for lead. The MCL for lead is 15 µg/L. There is no Tap Water RSL for lead.

Total Lead

Below is a brief summary of groundwater sample results for total lead in WBZ1.

- Samples from 12 MWs (52 percent) exceeded the MCL for at least one round of sampling.
- Samples from eight MWs (35 percent) exceeded the MCL for every round of sampling.
- The maximum detected total lead concentration was 1,740 µg/L in a sample from MW MW17 (field duplicate sample) collected in June 2008.

Dissolved Lead

Below is a brief summary of groundwater sample results for dissolved lead in WBZ1.

- Samples from five MWs (22 percent) exceeded the MCL for at least one round of sampling.
- Samples from four MWs (17 percent) exceeded the MCL for every round of sampling.
- The maximum detected dissolved lead concentration was 159 µg/L in a sample from MW MW31 collected in March 2009.

Generally, the detected total lead concentrations in the WBZ1 MWs exceeded the MCL and the detected dissolved lead concentrations were less than the MCL (Table 4.2.5-3 and Appendix S-35). When lead concentrations exceeded the CRQL, the dissolved lead results were significantly less than the total lead results. Turbidity largely affects lead concentrations in groundwater. Because lead does not readily dissolve in groundwater, the lead detected in the unfiltered samples likely is attributable to particulate matter in the samples.

Data for four MWs, MW02S, MW07, MW12, and MW24, suggest a trend of decreasing lead concentrations (Appendix S-35). The total and dissolved lead detected concentrations in these four wells decreased from November 2007 (or September 2008, depending on the well installation date) through October 2009. The total lead concentrations were significantly higher than the dissolved lead concentrations. No MWs show a trend of increasing lead concentrations. In addition, samples from three MWs, MW17, MW25, and MW31, had steady lead concentrations that exceeded the CRQL and were at or exceeded the MCL; however, no increasing or decreasing trend is evident.

Figures 4.2.5-11 and 4.2.5-12 show dissolved lead plumes for WBZ1 MWs based on December 2008 and June 2009 data, respectively. The figures both show dissolved lead concentrations in the center of the former main industrial area at OU2. The highest dissolved lead concentrations were located in the central portion of OU2, and lead concentrations decreased to the north and south.

Mercury

All 23 WBZ1 MWs were sampled for mercury. The Tap Water RSL and MCL for mercury are 0.57 and 52 µg/L, respectively.

Total Mercury

Below is a brief summary of groundwater sample results for total mercury in WBZ1.

- Samples from two MWs (9 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from one MW (4 percent) exceeded the MCL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected total mercury concentration was 4.1 µg/L in a sample from MW MW07 (field duplicate sample) collected in November 2007.

Dissolved Mercury

Below is a brief summary of groundwater sample results for dissolved mercury in WBZ1.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL.
- Samples from none of the MWs (0 percent) exceeded the MCL.
- The maximum detected dissolved mercury concentration was 0.26 µg/L in a sample from MW MW17 collected in October 2009.

With limited exceptions, the detected mercury concentrations in samples collected from the WBZ1 MWs were less than the CRQL and therefore less than the MCL and Tap Water RSL (Table 4.2.5-3 and Appendix S-35). When mercury concentrations exceeded the CRQL, the dissolved results were significantly less than the total results. Turbidity affects mercury concentrations in groundwater.

Because mercury does not readily dissolve in groundwater, the mercury detected in the unfiltered samples likely is attributable to particulate matter in the samples.

Data for one MW, MW07, suggest a trend of decreasing mercury concentrations (Appendix S-35). The detected total and dissolved mercury concentrations in MW07 decreased from November 2007 through October 2009. The total mercury concentrations were significantly higher than the dissolved results, and both the total and dissolved results show a decreasing trend in MW07.

No plume contour maps were created for the WBZ1 mercury results because of the limited number of detections.

Zinc

All 23 WBZ1 MWs were sampled for zinc. The Tap Water RSL for zinc is 11,000 µg/L. There is no MCL for zinc.

Total Zinc

Below is a brief summary of groundwater sample results for total zinc in WBZ1.

- Samples from 10 MWs (43 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from seven MWs (30 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected total zinc concentration was 113,000 µg/L in a sample from at well MW31 collected in September 2008.

Dissolved Zinc

Below is a brief summary of groundwater sample results for dissolved zinc in WBZ1.

- Samples from nine MWs (39 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from seven MWs (30 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected dissolved zinc concentration was 143,000 µg/L in a sample from MW MW31 collected in March 2009.

Generally, zinc concentrations in the WBZ1 MWs exceeded the CRQL and the total and dissolved zinc concentrations were similar (Table 4.2.5-3 and Appendix S-35). Turbidity does not appear to have affected zinc concentrations.

Data for one MW, MW31, suggest a trend of decreasing zinc concentrations (Appendix S-35). The total and dissolved zinc concentrations steadily decreased from December 2008 through October 2009. Data for MWs MW06, MW11, and MW12 suggest that the total and dissolved zinc concentrations may be increasing. Samples from five MWs, MW07, MW09, MW17, MW24, and MW25, had steady zinc concentrations that exceeded the CRQL and were at or exceeded the Tap Water RSL; however, no increasing or decreasing trend is evident.

Figures 4.2.5-15 and 4.2.5-16 show dissolved zinc plumes for WBZ1 MWs based on December 2008 and June 2009 data, respectively. The figures both show dissolved zinc concentrations centered on the former main industrial area at OU2. Both figures show the highest zinc concentrations in the central portion of OU2, although dissolved zinc was detected across all of WBZ1 groundwater. The highest dissolved zinc concentrations were located in the central portion of OU2, and concentrations decreased to the north and south.

Other Metals

“Other metals” are a secondary group comprising metals detected more often than not in the groundwater samples. However, the spatial extents of these detected metals are not as great or the metal is not as potentially harmful as the metals individually discussed above (arsenic, cadmium, lead, mercury, and zinc). “Other metals” does not include the metals individually discussed above or the nutrient metals that do not have exceedance criteria (calcium, magnesium, potassium, and sodium). The secondary group of metals includes aluminum, antimony, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, thallium, and vanadium.

All 23 WBZ1 MWs were sampled for other metals. During the March 2009 sampling event, the samples were analyzed for metals using the ICP-mass spectroscopy method instead of the ICP-AES method. Therefore the samples from March 2009 were not analyzed for aluminum, calcium, iron, magnesium, potassium, or sodium. Table 4.2.5-3 summarizes the detected other metals results for the WBZ1 groundwater samples. Groundwater sample results exceeded the Tap Water RSLs or MCLs for the following compounds: antimony, chromium, cobalt, iron, manganese, selenium, and thallium. GWSVs and total and dissolved results for each metal are summarized below.

Total Antimony

The Tap Water RSL and MCL for antimony are 15 and 6 µg/L, respectively. Below is a brief summary of groundwater sample results for total antimony in WBZ1.

- Samples from three MWs (13 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from nine MWs (39 percent) exceeded the MCL for at least one round of sampling.
- Samples from five MWs (22 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected total antimony concentration was 20 µg/L in a sample from MW MW31 collected in September 2008.

Dissolved Antimony

Below is a brief summary of groundwater sample results for dissolved antimony in WBZ1.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL.
- Samples from one location (4 percent) exceeded the MCL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected total antimony concentration was 8.6 µg/L in a sample from MW MW31 collected in December 2008.

As mentioned in the fifth paragraph of [Section 4.2.5](#), the CRQL for antimony exceeded the Tap Water RSL and MCL. The exceedances described above for total antimony in WBZ1 groundwater all occurred during the same sampling round in September 2008 (Table 4.2.5-3). For all other sampling rounds, antimony concentrations were below the CRQL and were flagged as non-detect. Therefore, the September 2008 results suggest an anomaly in which the laboratory detection limit was lower than the CRQL, and the antimony values are reported as detected values. All the September 2008 detected antimony results are flagged with a “J” to indicate that the value is estimated. For these reasons, graphs of the antimony exceedances over time were not created. Because all the antimony exceedances were for samples collected from the same sampling round (September 2008), no trends were noted in the WBZ1 groundwater antimony results. In terms of nature and extent for WBZ1, antimony in groundwater is not considered to be a COI and is not included in the WBZ1 summary below, nor it is included in the nature

and extent summary in [Section 4.3](#). However, antimony is evaluated for risk and included in the HHRA that is presented in Appendix RA.

No plume contour maps were created for WBZ1 antimony results because of the limited number of detections.

Total Chromium

The MCL for chromium is 100 µg/L. There is no Tap Water RSL for chromium. Below is a brief summary of groundwater sample results for total chromium in WBZ1.

- Samples from one MW (4 percent) exceeded the MCL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the MCL for every round of sampling.
- The maximum detected total cobalt concentration was 617 µg/L in a sample from MW MW10 collected in June 2008.

Dissolved Chromium

Below is a brief summary of groundwater sample results for dissolved chromium in WBZ1.

- Samples from none of the MWs (0 percent) exceeded the MCL.
- The maximum detected dissolved chromium concentration was 10.6 µg/L in a sample from MW MW08 collected in December 2008.

For all but one sampling round, chromium concentrations were below the MCL for WBZ1 groundwater results (Table 4.2.5-3). Because only one sample result exceeded the MCL, no trends were noted for the WBZ1 groundwater chromium results.

No plume contour maps were created for WBZ1 chromium results because of the limited number of detections.

Total Cobalt

The Tap Water RSL value for cobalt is 11 µg/L. There is no MCL for cobalt. Below is a brief summary of groundwater sample results for total cobalt in WBZ1.

- Samples from seven MWs (30 percent) exceeded the Tap Water RSL for at least one round of sampling.

- Samples from two MWs (9 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected total cobalt concentration was 7,080 µg/L in a sample from at well MW04 collected in March 2008.

Dissolved Cobalt

Below is a brief summary of groundwater sample results for dissolved cobalt in WBZ1.

- Samples from seven MWs (30 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from five MWs (22 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected dissolved cobalt concentration was 7,010 µg/L in a sample from at well MW04 collected in December 2008.

Generally, total and dissolved cobalt concentrations in the WBZ1 MWs exceeded the CRQL and were similar (Table 4.2.5-3 and Appendix S-36). When the samples were analyzed using the ICP-AES method in December 2008, the cobalt CRQL was 50 µg/L. Therefore, many sample results from the December 2008 sampling round are reported as less than the CRQL. When the samples were analyzed using the ICP-mass spectroscopy method in June 2009, more sample results exceeded the CRQL. Turbidity does not appear to have affected cobalt concentrations.

Data for MW MW17 suggest a trend of decreasing cobalt concentrations (Appendix S-36). The detected total and dissolved cobalt concentrations steadily decreased from November 2007 through October 2009. No increasing cobalt concentration trends were noted in WBZ1 sample results. Samples from three MWs, MW04, MW07, and MW21, have had variable cobalt concentrations exceeding the CRQL and the Tap Water RSL. However, no increasing or decreasing trend is evident.

Figures 4.2.5-19 and 4.2.5-20 show dissolved cobalt plumes for WBZ1 MWs based on December 2008 and June 2009 data, respectively. Figure 4.2.5-19 shows dissolved cobalt concentrations centered on the former main industrial area at OU2, with additional concentrations exceeding the Tap Water RSL on the southern edge of OU2. Figure 4.2.5-20 shows dissolved cobalt concentrations exceeding the Tap Water RSL across the former main industrial area of OU2.

Total Iron

The Tap Water RSL for iron is 26,000 µg/L. There is no MCL for iron. Below is a brief summary of groundwater sample results for total iron in WBZ1.

- Samples from three MWs (13 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected total iron concentration was 109,000 µg/L in a sample from MW MW17 (field duplicate sample) collected in March 2008.

Dissolved Iron

Below is a brief summary of groundwater sample results for dissolved iron in WBZ1.

- Samples from two MWs (9 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from one MW (4 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected dissolved iron concentration was 82,500 µg/L in a sample from MW MW17 (field duplicate sample) collected in December 2008.

Generally, iron concentrations exceeded the CRQL and the total and dissolved iron concentrations in the WBZ1 MWs were similar (Table 4.2.5-3 and Appendix S-36). Turbidity does not appear to have affected iron concentrations.

Data from two MWs, MW10, and MW17, suggest a trend of decreasing iron concentrations (Appendix S-36). The detected total and dissolved iron concentrations in both MWs steadily decreased from November 2007 through October 2009. No other increasing or decreasing trends were evident based on WBZ1 groundwater results for iron.

No plume contour maps were created for WBZ1 iron results because of the limited number of detections.

Total Manganese

The Tap Water RSL value for manganese is 880 µg/L. There is no MCL for manganese. Below is a brief summary of groundwater sample results for total manganese in WBZ1.

- Samples from 13 MWs (57 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from 12 MWs (52 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected total manganese concentration was 40,100 µg/L in a sample from MW MW25 collected in September 2008.

Dissolved Manganese

Below is a brief summary of groundwater sample results for dissolved manganese in WBZ1.

- Samples from 12 MWs (52 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from eight MWs (35 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected dissolved manganese concentration was 153,000 µg/L in a sample from MW MW04 collected in December 2008.

Generally, total and dissolved manganese concentrations in the WBZ1 MWs exceeded the CRQL and were similar (Table 4.2.5-3 and Appendix S-36). Turbidity does not appear to have affected manganese concentrations.

Data for four MWs, MW07, MW09, MW11, and MW17, suggest a trend of decreasing manganese concentrations (Appendix S-36). The total and dissolved manganese concentrations steadily decreased from November 2007 (or September 2008, depending well installation date) through October 2009. Data from MW MW29 suggests that total and dissolved manganese concentrations may be increasing. Samples from three MWs, MW12, MW21, and MW25, had steady manganese concentrations that exceeded the CRQL and were at or exceeded the Tap Water RSL; however, no increasing or decreasing trend is evident. Additionally, samples from MWs MW04 and MW10 had variable manganese concentrations that exceeded the CRQL and were at or above the Tap Water RSL. However, no increasing or decreasing trend is evident.

Figures 4.2.5-23 and 4.2.5-24 show dissolved manganese plumes for WBZ1 MWs based on December 2008 and June 2009 data, respectively. Figure 4.2.5-23 shows dissolved manganese concentrations centered on the former main industrial area at OU2, with additional concentrations on the southern edge of OU2. Figure 4.2.5-24 shows three plumes of dissolved manganese concentrations exceeding the Tap Water RSL in WBZ2 at OU2.

Total Selenium

The Tap Water RSL and MCL for selenium are 180 and 50 µg/L, respectively. Below is a brief summary of groundwater sample results for total selenium in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from two MWs (9 percent) exceeded the MCL for at least one round of sampling.
- Samples from two MWs (9 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected total selenium concentration was 245 µg/L in a sample from MW MW24 (field duplicate sample) collected in September 2008.

Dissolved Selenium

Below is a brief summary of groundwater sample results for dissolved selenium in WBZ1.

- Samples from two MWs (9 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from two MWs (9 percent) exceeded the MCL for at least one round of sampling.
- Samples from two MWs (9 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected dissolved selenium concentration was 222 µg/L in a sample from MW MW24 (field duplicate sample) collected in December 2008.

Generally, total and dissolved selenium concentration were less than the CRQL in the WBZ1 MWs (Table 4.2.5-3 and Appendix S-36). Turbidity does not appear to have affected selenium concentrations.

Samples from two MWs, MW04 and MW24, had variable selenium concentrations that exceeded the CRQL and were at or exceeded the Tap Water RSLs; however, no increasing or decreasing trend is evident.

No plume contour maps were created for the WBZ1 selenium results because of the limited number of detections.

Total Thallium

The MCL for thallium is 2 µg/L. There is no Tap Water RSL for thallium. Below is a brief summary of groundwater sample results for total thallium in WBZ1.

- Samples from nine MWs (39 percent) exceeded the MCL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the MCL for every round of sampling.
- The maximum detected total thallium concentration was 5.5 µg/L in a sample from MW MW07 collected in November 2007.

Dissolved Thallium

Below is a brief summary of groundwater sample results for dissolved thallium in WBZ1.

- Samples from none of the MWs (0 percent) exceeded the MCL.
- The maximum detected dissolved thallium concentration was 1.8 µg/L in a sample from MW MW17 collected in June 2009.

As mentioned in the fifth paragraph of [Section 4.2.5](#), the CRQL for thallium exceeded the MCL.

Thallium non-detected results for the WBZ1 samples frequently exceeded the MCL. However, the results did not exceed the CRQL and therefore are not considered to have exceeded the MCL. Thallium concentrations in one well, MW17, exceeded the MCL, and the data suggest that thallium concentrations decreased between sampling events (Table 4.2.5-3 and Appendix S-36). The detected total and dissolved thallium concentrations steadily decreased at well MW17 from November 2007 through October 2009. No other trends were noted in the WBZ1 groundwater thallium results.

No plume contour maps were created for WBZ1 thallium results because of the limited number of detections.

Cyanide

Groundwater samples from the following rounds and wells were analyzed for cyanide: November 2007 (select wells), March 2008 (all wells), June 2008 (all wells), September 2008 (all wells), December 2008 (Phase II wells only), March 2009 (Phase II wells only), June 2009 (Phase II wells only), and October 2009 (dissolved samples only). Table 4.2.5-1 summarizes the compounds analyzed for in each well during each sampling round. In Table 4.2.5-3, the groundwater metals results summary table, samples not analyzed for cyanide are marked as "--." Total and dissolved results for the WBZ1 groundwater samples

analyzed for cyanide are summarized below. The Tap Water RSL and MCL for cyanide are 730 and 200 µg/L, respectively.

Total Cyanide

Below is a brief summary of groundwater sample results for total cyanide in WBZ1.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL.
- Samples from one MW (4 percent) exceeded the MCL.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected dissolved total cyanide concentration was 302 µg/L in a sample from MW MW04 collected in March 2008.

Dissolved Cyanide

Below is a brief summary of groundwater sample results for dissolved cyanide in WBZ1.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL.
- Samples from one MW (4 percent) exceeded the MCL.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL value for every round of sampling.
- The maximum detected dissolved total cyanide concentration was 239 µg/L in a sample from MW MW04 collected in October 2009.

Cyanide was not detected in any samples at concentrations exceeding the Tap Water RSL. For all but one MW, MW04, cyanide concentrations were below the MCL. Samples from MW MW04 contained cyanide at concentrations near the MCL, and the data suggest that cyanide concentrations increased between sampling events (Appendix S-36). The detected total and dissolved cyanide concentrations steadily increased at well MW04 from November 2007 through October 2009. Because only one total and one dissolved sample result exceeded the MCL, no other trends are evident for the WBZ1 groundwater cyanide results.

No plume contour maps were created for WBZ1 cyanide results because of the limited number of detections.

VOCs

All 23 WBZ1 MWs were sampled for VOCs. Table 4.2.5-4 summarizes the detected VOC results for WBZ1 and WBZ2 groundwater. Figure 4.2.5-27 shows the VOC results for both the WBZ1 and WBZ2 MWs that exceeded the MCLs and Tap Water RSLs. All VOC samples were unfiltered. Appendix S-37 presents the full set of groundwater VOC results. Figures 1 through 4 in Appendix S-38 show the VOC results for selected wells. WBZ1 groundwater results exceeded the Tap Water RSL or MCL values for the following VOCs: benzene; cis-1,2-DCE; ethylbenzene; PCE; TCE; and VC. Results for the individual VOC analytes exceeding the GWSVs are discussed below based on the number of Tap Water RSL and MCL exceedances.

Benzene

The Tap Water RSL and MCL for benzene are 0.41 and 5 µg/L, respectively. Below is a brief summary of groundwater sample results for benzene in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the MCL.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected benzene concentration was 1.7 µg/L in a samples from MW MW10 collected in March 2008.

Cis-1,2-Dichloroethene

The Tap Water RSL and MCL for cis-1,2- DCE are 370 and 70 µg/L, respectively. Below is a brief summary of groundwater sample results for cis-1,2-DCE in WBZ1.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL.
- Samples from one MW (4 percent) exceeded the MCL for at least one round of sampling
- Samples from none of the MWs exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected cis-1,2-DCE concentration was 240 µg/L in a sample from MW MW04 collected in March 2008.

Ethylbenzene

The Tap Water RSL and MCL for ethylbenzene are 1.5 and 700 µg/L, respectively. Below is a brief summary of groundwater sample results for ethylbenzene in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the MCL.
- Samples from none of the MWs exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected ethylbenzene concentration was 36 µg/L in a sample from MW MW10 collected in March 2008.

Tetrachloroethene

The Tap Water RSL and MCL for PCE are 0.11 and 5 µg/L, respectively. Below is a brief summary of groundwater sample results for PCE in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the MCL.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected PCE concentration was 0.5 µg/L in a sample from MW MW30 collected in March 2009.

Trichloroethene

The Tap Water RSL and MCL for TCE are 1.7 and 5 µg/L, respectively. Below is a brief summary of groundwater sample results for TCE in WBZ1.

- Samples from two MWs (9 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from two MWs (9 percent) exceeded the MCL for at least one round of sampling.
- Samples from two MWs (9 percent) exceeded the Tap Water RSL or MCL for every round of sampling.

- The maximum detected TCE concentration was 230 µg/L in a sample from MW MW04 collected in March 2008.

Vinyl Chloride

The Tap Water RSL and MCL for VC are 0.016 and 2 µg/L, respectively. Below is a brief summary of groundwater sample results for VC in WBZ1.

- Samples from two MWs (9 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from one MW (4 percent) exceeded the MCL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected VC concentration was 18 µg/L in a sample from MW MW04 collected in March 2008.

VOCs were detected at concentrations at or exceeding the Tap Water RSLs or MCLs for multiple analytes and sampling rounds in samples from four WBZ1 MWs (MW04, MW10, MW30, and MW31). Three of the wells, MW04, MW30, and MW31, are located near the former Rolling Mill building, which is on the southern border of OU2. Sample results for three wells exceeded the Tap Water RSLs or MCLs for chlorinated VOCs (cVOCs), particularly cis-1,2-DCE, PCE, TCE, and VC, during multiple rounds of sampling (Figures 1 and 3 in Appendix S-38 and Figure 4.2.5-27). The highest cVOC concentration detected was for TCE. The presence of PCE and the relatively high TCE concentrations suggest that a release of PCE or TCE may have occurred and that cis-1,2-DCE and VC may be present as breakdown products. For MW04, the peaks and troughs for each cVOC diagram align with the maximum concentrations detected in samples collected in March 2008. Each cVOC diagram for MW04 also shows a decrease during the next two rounds of sampling (June and September 2008). From September 2008 through October 2009, the cVOC concentrations in MW04 slowly increased to approximately three-quarters of the maximum concentration detected in March 2008. For MW30, the VC concentration increased between December 2008 and October 2009, suggesting that VC may be produced through reductive dechlorination of VC's parent products PCE; TCE; and cis-1,2-DCE. In MW10, benzene and ethylbenzene were detected at concentrations exceeding the Tap Water RSLs, and both compounds commonly are associated with petroleum products. The ethylbenzene and benzene concentrations in MW10 exceed the lower of the Tap Water RSLs. However, the MW10 ethylbenzene and benzene

concentrations were considerably below the MCLs. MW10 is located beside ASTs, suggesting that a release of petroleum materials may have occurred to the surface near MW10.

SVOCs

All 23 WBZ1 MWs were sampled for SVOCs. Table 4.2.5-5 summarizes the detected SVOC results for WBZ1 and WBZ2 groundwater. No plume contour maps were created for WBZ1 or WBZ2 SVOC results because of the limited number of detections. All SVOC samples were unfiltered. Appendix S-39 presents the full set of groundwater SVOC results. WBZ1 groundwater results exceeded the Tap Water RSL or MCL values for the following PAH compounds: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, naphthalene, and pentachlorophenol. Results for the individual SVOC analytes are discussed below based on the number of Tap Water RSL and MCL exceedances.

Benzo(a)anthracene

The Tap Water RSL for benzo(a)anthracene is 0.029 µg/L. There is no MCL for benzo(a)anthracene. Below is a brief summary of groundwater sample results for benzo(a)anthracene in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected benzo(a)anthracene concentration was 0.67 µg/L in a sample from MW MW12 collected in March 2008.

Benzo(a)pyrene

The Tap Water RSL and MCL for benzo(a)pyrene are 0.0029 and 0.2 µg/L, respectively. Below is a brief summary of groundwater sample results for benzo(a)pyrene in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the MCL.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected benzo(a)pyrene concentration was 0.19 µg/L in a sample from MW MW12 collected in December 2008.

Benzo(b)fluoranthene

The Tap Water RSL for benzo(b)fluoranthene is 0.029 µg/L. There is no MCL for benzo(a)anthracene. Below is a brief summary of groundwater sample results for benzo(b)fluoranthene in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected benzo(b)fluoranthene concentration was 0.59 µg/L in a sample from MW MW12 collected in March 2008.

Benzo(g,h,i)perylene

The Tap Water RSL for benzo(g,h,i)perylene is 0.029 µg/L. There is no MCL for benzo(g,h,i)perylene. Below is a brief summary of groundwater sample results for benzo(g,h,i)perylene in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected benzo(g,h,i)perylene concentration was 0.42 µg/L in a sample from MW MW12 collected in March 2008.

Benzo(k)fluoranthene

The Tap Water RSL for benzo(k)fluoranthene is 0.29 µg/L. There is no MCL for benzo(k)fluoranthene. Below is a brief summary of groundwater sample results for benzo(k)fluoranthene in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected benzo(k)fluoranthene concentration was 0.5 µg/L in a sample from MW MW12 collected in March 2008.

Bis(2-ethylhexyl)phthalate

The Tap Water RSL and MCL for bis(2-ethylhexyl)phthalate are 4.8 and 6 µg/L, respectively. Below is a brief summary of groundwater sample results for bis(2-ethylhexyl)phthalate in WBZ1.

- Samples from three MWs (13 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from three MWs (13 percent) exceeded the MCL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL value for every round of sampling.
- The maximum detected bis(2-ethylhexyl)phthalate concentration was 16 µg/L in a sample from MW MW10 collected in November 2007.

Dibenzo(a,h)anthracene

The Tap Water RSL for dibenzo(a,h)anthracene is 0.029 µg/L. There is no MCL for dibenzo(a,h)anthracene. Below is a brief summary of groundwater sample results for dibenzo(a,h)anthracene in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected dibenzo(a,h)anthracene concentration was 0.04 µg/L in a sample from MW MW12 collected in October 2009.

Indeno(1,2,3-cd)pyrene

The Tap Water RSL for indeno(1,2,3-cd)pyrene is 0.029 µg/L. There is no MCL for indeno(1,2,3-cd)pyrene. Below is a brief summary of groundwater sample results for indeno(1,2,3-cd)pyrene in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected indeno(1,2,3-cd)pyrene concentration was 0.33 µg/L in a sample from MW MW12 collected in March 2008.

Naphthalene

The Tap Water RSL for naphthalene is 0.14 µg/L. There is no MCL for naphthalene. Below is a brief summary of groundwater sample results for naphthalene in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected naphthalene concentration was 37 µg/L in a sample from MW MW10 collected in March 2009.

Pentachlorophenol

The Tap Water RSL and MCL for pentachlorophenol are 0.56 and 1.0 µg/L, respectively. Below is a brief summary of groundwater sample results for pentachlorophenol in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected pentachlorophenol concentration was 0.7 µg/L in a sample from MW MW29 collected in October 2009.

SVOCs were detected at concentrations at or exceeding the Tap Water RSLs or MCLs at five WBZ1 MWs (MW02S, MW10, MW12, MW27, and MW29). Sample results for two of the WBZ1 MWs, MW10 and MW12, exceeded the Tap Water RSLs or MCLs for multiple PAH compounds. No contaminants were detected during every round of sampling at a single well. Sample results for MW10 exceeded the Tap Water RSLs and MCLs for naphthalene and bis(2-ethylhexyl)phthalate during multiple

rounds of sampling. As noted above, MW10 is located beside ASTs, suggesting that a release of petroleum materials may have occurred to the surface near MW10. Sample results for MW12 exceeded the Tap Water RSL for multiple sampling rounds for the following compounds: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene. No increasing or decreasing trends were evident for SVOCs in WBZ1 MWs.

PCBs

All 23 WBZ1 MWs were sampled for PCBs. Table 4.2.5-6 summarizes the detected PCB results for WBZ1 and WBZ2 groundwater. No plume contour maps were created for WBZ1 or WBZ2 PCB results because of the limited number of detections. All PCB samples were unfiltered. Appendix S-40 presents the full set of groundwater PCB results. Results for the individual PCB analytes are discussed below based on the number of Tap Water RSL and MCL exceedances.

The Tap Water RSL and MCL for the PCB Aroclors detected in WBZ1 groundwater (Aroclor-1248 and Aroclor-1254) are 0.034 and 0.5 µg/L, respectively.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for Aroclor-1248 for one round of sampling.
- Samples from one MW (4 percent) exceeded the Tap Water RSL for Aroclor-1254 for one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the MCL for Aroclor-1248 and Aroclor-1254.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected PCB (Aroclor 1248) concentration was 0.47 µg/L at MW07 (field duplicate sample) in September 2008.
- The maximum detected PCB (Aroclor-1254) concentration was 0.28 µg/L in a sample from MW30 collected in June 2009.

PCB Aroclor-1248 and Aroclor-1254 were detected at concentrations at or exceeding the Tap Water RSL at two WBZ1 MWs, MW07 and MW30, respectively. PCB Aroclor-1248 and Aroclor-1254 concentrations did not exceed the MCL in WBZ1 MWs. Sample results for none of the WBZ1 MWs exceeded the Tap Water RSL for the same Aroclor during multiple rounds of sampling, nor was any Aroclor detected more than once at a single MW. No trends are evident for PCBs in WBZ1 MWs.

Pesticides

All 23 WBZ1 MWs were sampled for pesticides. Table 4.2.5-7 summarizes the detected pesticide results for WBZ1 and WBZ2 groundwater. No plume contour maps were created for WBZ1 or WBZ2 pesticides results because of the limited number of detections. All pesticides samples were unfiltered. Appendix S-41 presents the full set of groundwater pesticides results. Results for the individual pesticides analytes are discussed below based on the number of Tap Water RSL and MCL exceedances.

Aldrin

The Tap Water RSL for aldrin is 0.004 µg/L. There is no MCL for aldrin. Below is a brief summary of groundwater sample results for aldrin in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected aldrin concentration was 0.015 µg/L in a sample from MW MW10 collected in June 2009.

Alpha-BHC

The Tap Water RSL for alpha-BHC is 0.011 µg/L. There is no MCL for alpha-BHC. Below is a brief summary of groundwater sample results for alpha-BHC in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected alpha-BHC concentration was 0.048 µg/L in a sample from MW MW10 collected in June 2009.

Beta-BHC

The Tap Water RSL for beta-BHC is 0.037 µg/L. There is no MCL for beta-BHC. Below is a brief summary of groundwater sample results for beta-BHC in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected beta-BHC concentration was 0.069 µg/L in a sample from MW MW10 collected in November 2007.

Delta-BHC

The Tap Water RSL for delta-BHC is 0.011 µg/L. There is no MCL for delta-BHC. Below is a brief summary of groundwater sample results for delta-BHC in WBZ1.

- Samples from eight MWs (35 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected delta-BHC concentration was 0.11 µg/L in a sample from MW MW10 collected in October 2009.

Heptachlor

The Tap Water RSL and MCL for heptachlor are 0.015 and 0.4 µg/L, respectively. Below is a brief summary of groundwater sample results for heptachlor in WBZ1.

- Samples from one MW (4 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the MCL.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL value for every round of sampling.
- The maximum detected heptachlor concentration was 0.061 µg/L in a sample from MW MW10 collected in June 2009.

Heptachlor Epoxide

The Tap Water RSL and MCL for heptachlor epoxide are 0.0074 and 0.2 µg/L, respectively. Below is a brief summary of groundwater sample results for heptachlor epoxide in WBZ1.

- Samples from eight MWs (35 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent)) exceeded the MCL.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected heptachlor epoxide concentration was 0.12 µg/L in a sample from MW MW10 collected in October 2009.

Pesticide compounds were detected at concentrations at or exceeding the Tap Water RSLs or MCLs at eleven WBZ1 monitoring locations. Sample results for none of the wells exceeded the Tap Water RSL or MCL for the same contaminant during multiple rounds of sampling, nor was any contaminant detected during every round of sampling at a single well. No increasing or decreasing trends were evident for pesticides in WBZ1 groundwater wells.

OU2 WBZ1 Summary

Groundwater sample results for WBZ1 for OU2 reveal that concentrations of the following exceeded the Tap Water RSLs or MCLs: total metals (arsenic, cadmium, lead, mercury, zinc, chromium, cobalt, iron, manganese, selenium, thallium, and cyanide), dissolved metals (arsenic, cadmium, lead, zinc, cobalt, iron, manganese, selenium, and cyanide), VOCs (benzene; cis-1,2-DCE; ethylbenzene; PCE; TCE; and VC), SVOCs (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, bis[2-ethylhexyl]phthalate, dibenzo[a,h]anthracene, indeno[1,2,3-cd]pyrene, naphthalene, and pentachlorophenol), PCBs (Aroclor-1248 and Aroclor-1254), and pesticides (aldrin, alpha-BHC, beta-BHC, delta-BHC, heptachlor, and heptachlor epoxide). As explained in [Section 4.2.5.1](#), in the antimony subsection, antimony is not considered a COI for nature and extent. Sample results for 16 WBZ1 MWs exceeded the Tap Water RSLs or MCLs during multiple rounds of sampling and exceeded the higher of the Tap Water RSL or MCL (if applicable). Fourteen of the wells (MW06, MW07, MW08, MW09, MW10, MW11, MW12, MW17, MW21, MW23, MW24, MW25, MW29, and MW31) are located in the central portion of OU2 around the former main industrial area. The remaining two wells (MW04 and MW30) are located on the northern side of the Rolling Mill building.

Metals (arsenic, cadmium, cobalt, lead, manganese, and zinc) sample results for all wells in the former main industrial area exceeded the Tap Water RSLs or MCLs. The WBZ1 MWs are screened through unconsolidated subsurface material and likely were contaminated by surface runoff infiltration. Wells of particular concern in the former main industrial area include MW07, MW09, MW10, MW11, MW17,

MW24, MW25, and MW31. Sample results for these wells exceeded the higher of the Tap Water RSL or MCL value (if applicable) for at least three different metals for multiple rounds of sampling. MWs MW07, MW17, and MW25 are located in the center of the former main industrial area, and sample results for all three wells exceeded the cadmium, manganese, and zinc Tap Water RSLs or MCLs for all rounds of sampling.

Sample results indicate a TCE release in two wells located on the northern side of the Rolling Mill building (MW04 and MW30). The release likely has migrated laterally and vertically toward the WBZ2 MW MW33. The presence of TCE concentrations suggest that a release of TCE may have occurred and that cis-1,2-DCE and VC may be present as breakdown products.

Sample results from two WBZ1 MWs, MW10 and MW12, exceeded the Tap Water RSLs for multiple PAH compounds. Sample results for MW10 exceeded the Tap Water RSLs and MCLs for naphthalene and bis (2-ethylhexyl)phthalate during multiple rounds of sampling. Well MW10 is located beside empty ASTs, suggesting that a release of a petroleum material may have occurred to the surface near MW10. PAH contamination is also localized around MW12 in the northern portion of the former main industrial area.

PCBs were detected by Rolling Mill building in MW30 and along the northern edge of the former furnaces in MW07. PCBs were not detected in any other MWs.

Pesticides were detected at a couple of localized WBZ1 MWs in the former main industrial area.

Overall, the WBZ1 groundwater sample results indicate that surficial contamination from historical operations has percolated into the subsurface unconsolidated aquifer.

4.2.5.2 OU2 WBZ2 MW Results

Thirteen MWs are screened in WBZ2 (Figure 4.2.5-1). These MWs were sampled quarterly from the date of installation through October 2009. Groundwater metals and cyanide, VOC, SVOC, PCB, and pesticides results are summarized below for the WBZ2 MWs. Tables 4.2.5-1 and 4.2.5-2 summarize the compounds analyzed for in each well during each sampling round and summarize Tap Water RSL and MCL exceedances at each MW, respectively. Tables 4.2.5-3 through 4.2.5-7 summarize the detected results. Figure 4.2.5-2 shows all MWs with sample results that exceeded the GWSVs in each analyte group (metals, VOCs, SVOCs, PCBs, and pesticides

Metals and Cyanide

All 13 WBZ2 MWs were sampled at least twice for metals and cyanide. A total of 85 discrete groundwater samples, excluding field duplicates, were submitted for metals analysis. The higher value from the duplicate or original sample was used to evaluate the data discussed below. Of the 86 samples analyzed, 52 were field filtered and represent dissolved metals concentrations. The remaining 34 of the 86 total samples were analyzed for total metals. Each WBZ2 MW has four filtered sample results except for MW32. The dissolved and total metals sample results are discussed separately below. Table 4.2.5-3 summarizes the detected dissolved and total metals results.

Appendix S-34 presents the full set of metals in groundwater results. Figures 1 through 36 in Appendix S-35 show the dissolved and total metals results for arsenic, cadmium, lead, mercury, and zinc for each round of sampling at each MW. Figures 1 through 6 in Appendix S-36 show the dissolved and total metals results for cobalt, cyanide, iron, manganese, selenium, and thallium, respectively. In the figures presented in Appendix S-35 and Appendix S-36, the CRQLs are shown for all results below the CRQLs, results at or below the CRQLs are shown in gray, and detected results are shown in black. Because of the large number of analytical detections and concentrations exceeding the Tap Water RSLs and MCLs, results for the individual metal analytes are discussed below based on the number of Tap Water RSL and MCL exceedances.

Arsenic

All 13 WBZ2 MWs were sampled for arsenic. The Tap Water RSL and MCL for arsenic are 0.045 and 10 µg/L, respectively.

Total Arsenic

Below is a brief summary of groundwater sample results for total arsenic in WBZ2.

- Samples from two MWs (15 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from one MW (8 percent) exceeded the MCL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected total arsenic concentration was 14.8 µg/L in a sample from MW MW02D collected in November 2007.

Dissolved Arsenic

Below is a brief summary of groundwater sample results for dissolved arsenic in WBZ2.

- Samples from 13 MWs (100 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the MCL for at least one round of sampling.
- Samples from one MW (8 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected dissolved arsenic concentration was 10 µg/L in a sample from MW MW10 collected in October 2009.

Generally, when arsenic concentrations exceeded the CRQL, the total and dissolved arsenic concentrations in the WBZ2 MWs were similar (Table 4.2.5-3 and Appendix S-35). Because the CRQL for arsenic frequently exceeded the Tap Water RSL and equaled the MCL, many of the arsenic results are listed as at or below the detection limit. When the CRQL exceeded the Tap Water RSL, the groundwater sample result could not be compared to the Tap Water RSL. When the samples were analyzed using the ICP-AES method, the arsenic CRQL was approximately 10 µg/L. When the samples were analyzed using the ICP-AES method, the arsenic CRQL was approximately 10 µg/L. When the samples were analyzed using the ICP-mass spectroscopy method, the arsenic CRQL was approximately 2 µg/L. The lower CRQL value for the ICP-mass spectroscopy method explains why more dissolved arsenic results exceeded the Tap Water RSL than total arsenic results. Turbidity does not appear to have affected arsenic concentrations.

Data for two MWs, MW02D and MW14, suggest a trend of decreasing arsenic concentrations (Appendix S-35). The detected total and dissolved arsenic concentrations steadily decreased from November 2007 (or September 2008, depending well installation date) through October 2009. Samples from two MWs, MW20, MW22, and MW23, had steady arsenic concentrations that exceeded the CRQL and were at or exceeded the Tap Water RSL; however, no increasing or decreasing trend is evident.

Figures 4.2.5-5 and 4.2.5-6 show dissolved arsenic plumes for WBZ2 MWs based on December 2008 and June 2009 data, respectively. Because the ICP-AES method was used in December 2008, the arsenic CRQL was 10 µg/L. Therefore, many sample results are reported as less than the CRQL. The ICP-mass spectroscopy method was used in June 2009, and more sample results are reported exceeding the CRQL. Figures 4.2.5-5 and 4.2.5-6 show multiple locations where arsenic sample results exceeded the CRQL; however, no locations exceeded the arsenic MCL of 10 µg/L.

Cadmium

All 13 WBZ2 MWs were sampled for cadmium. The Tap Water RSL and MCL for cadmium are 18 and 5 µg/L, respectively.

Total Cadmium

Below is a brief summary of groundwater sample results for total cadmium in WBZ2.

- Samples from none of the MW locations (0 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from one MW location (8 percent) exceeded the MCL for at least one round of sampling.
- Samples from one MW location (8 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected total cadmium concentration was 15.5 µg/L in a sample from MW MW18 collected in June 2008.

Dissolved Cadmium

Below is a brief summary of groundwater sample results for dissolved cadmium in WBZ2.

- Samples from two MW locations (15 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from four MW locations (31 percent) exceeded the MCL for at least one round of sampling.
- Samples from one MW location (8 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected dissolved cadmium concentration was 101 µg/L in a sample from MW MW13 collected in December 2008.

Generally, the detected total and dissolved cadmium concentrations in the WBZ2 MWs exceeded the MCL and Tap Water RSL (Table 4.2.5-3 and Appendix S-35). When cadmium concentrations exceeded the CRQL, the total and dissolved cadmium results were similar. Turbidity does not appear to have affected cadmium concentrations.

Samples from one MW, MW18, had steady cadmium concentrations that exceeded the MCL but were below the Tap Water RSL; however, no increasing or decreasing trend is evident. No other MWs showed trends in cadmium concentrations exceeding the GWSVs.

Figures 4.2.5-9 and 4.2.5-10 show dissolved cadmium plumes for WBZ2 MWs based on December 2008 and June 2009 data, respectively. The figures both show dissolved cadmium concentrations increasing from west to east across OU2. The highest dissolved cadmium concentrations are located along the eastern border of OU2. The cadmium contours align with the projected groundwater flow direction in WBZ2 MWs.

Lead

All 13 WBZ2 MWs were sampled for lead. The MCL for lead is 15 µg/L. There is no Tap Water RSL for lead.

Total Lead

Below is a brief summary of groundwater sample results for total lead in WBZ2.

- Samples from five MW locations (38 percent) exceeded the MCL for at least one round of sampling.
- Samples from three MW locations (23 percent) exceeded the MCL for every round of sampling.
- The maximum detected total lead concentration was 135 µg/L in a sample from MW MW02D (field duplicate sample) collected in June 2008.

Dissolved Lead

Below is a brief summary of groundwater sample results for dissolved lead in WBZ2.

- Samples from one MW (8 percent) exceeded the MCL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the MCL for every round of sampling.
- The maximum detected dissolved lead concentration was 28.7 µg/L in a sample from MW MW19 collected in June 2009.

Generally, the detected total and dissolved lead concentrations in the WBZ2 MWs were less than the CRQL and MCL (Table 4.2.5-3 and Appendix S-35). When lead concentrations exceeded the CRQL, the dissolved lead results were significantly less than the total lead results. Turbidity largely affects lead

concentrations in groundwater. Because lead does not readily dissolve in groundwater, the lead detected in the unfiltered samples likely is attributable to particulate matter in the samples.

Because few of the sample results exceeded the CRQL and MCL, no trends were noted for the WBZ2 groundwater lead results.

Figures 4.2.5-13 and 4.2.5-14 show dissolved lead plumes for WBZ2 MWs based on December 2008 and June 2009 data, respectively. Figure 4.2.5-13 shows detected dissolved lead concentrations around the former main industrial area at OU2, and all of the detected results were below the MCL. Figure 4.2.5-14 shows dissolved lead concentrations along the southern to eastern edge of OU2, with one location exceeding the MCL.

Mercury

All 13 WBZ2 MWs were sampled for mercury. The Tap Water RSL and MCL for mercury are 0.57 and 52 µg/L, respectively.

Total Mercury

Below is a brief summary of groundwater sample results for total mercury in WBZ2.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL.
- Samples from none of the MWs (0 percent) exceeded the MCL.
- The maximum detected total mercury concentration was 0.11 µg/L in a sample from MW MW02D (field duplicate sample) collected in November 2007.

Dissolved Mercury

Below is a brief summary of groundwater sample results for dissolved mercury in WBZ2.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL.
- Samples from none of the MWs (0 percent) exceeded the MCL.
- All of the dissolved mercury sample results were below the detection limit of 0.2 µg/L.

All total and dissolved mercury concentrations in samples collected from the WBZ2 MWs were less than the Tap Water RSL, MCL, or CRQL (Table 4.2.5-3 and Appendix S-35). Because few of the sample

results exceed the CRQL and no results exceeded the Tap Water RSL or MCL, no increasing or decreasing trends were noted for the WBZ2 groundwater mercury results.

No plume contour maps were created for the WBZ2 mercury results because of the limited number of detections.

Zinc

All 13 WBZ2 MWs were sampled for zinc. The Tap Water RSL for zinc is 11,000 µg/L. There is no MCL for zinc.

Total Zinc

Below is a brief summary of groundwater sample results for total zinc in WBZ2.

- Samples from one MW (8 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from one MW (8 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected total zinc concentration was 26,600 µg/L in a sample from MW MW18 (field duplicate sample) collected in September 2008.

Dissolved Zinc

Below is a brief summary of groundwater sample results for dissolved zinc in WBZ2.

- Samples from three MWs (23 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from one MW (8 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected dissolved zinc concentration was 26,500 µg/L in a sample from MW MW18 collected in March 2009.

Generally, zinc concentrations in the WBZ2 MWs exceeded the CRQL and the total and dissolved zinc concentrations were similar (Table 4.2.5-3 and Appendix S-35). Turbidity does not appear to have affected zinc concentrations.

Samples from one MW, MW18, had steady zinc concentrations that exceeded the CRQL and were at or exceeded the Tap Water RSL or MCL; however, no increasing or decreasing trend is evident. No other zinc trends were noted for the WBZ2 MWs.

Figures 4.2.5-17 and 4.2.5-18 show dissolved zinc plumes for WBZ2 MWs based on December 2008 and June 2009 data, respectively. The figures both show dissolved zinc concentrations centered on the former main industrial area at OU2. Both figures show the highest zinc concentrations on the eastern edge of OU2. The contours align with the projected groundwater flow direction in WBZ2 MWs.

Other Metals

“Other metals” are a secondary group comprising metals detected more often than not in the groundwater samples. However, the spatial extents of these detected metals are not as great or the metal is not as potentially harmful as the metals individually discussed above (arsenic, cadmium, lead, mercury, and zinc). “Other metals” does not include the metals individually discussed above or the nutrient metals that do not have exceedance criteria (calcium, magnesium, potassium, and sodium). The secondary group of metals includes aluminum, antimony, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, thallium, and vanadium.

All 13 WBZ2 MWs were sampled for other metals. During the March 2009 sampling event, the samples were analyzed for metals using the ICP-mass spectroscopy method instead of the ICP-AES method. Therefore the samples from March 2009 were not analyzed for aluminum, calcium, iron, magnesium, potassium, or sodium. Table 4.2.5-3 summarizes the detected other metals results for the WBZ2 groundwater samples. Groundwater sample results exceeded the Tap Water RSLs or MCLs for the following compounds: aluminum, antimony, cobalt, iron, manganese, and thallium. GWSVs and total and dissolved results for each metal are summarized below.

Total Aluminum

The Tap Water RSL for aluminum is 37,000 µg/L. There is no MCL for aluminum. Below is a brief summary of groundwater sample results for total aluminum in WBZ2.

- Samples from one MW (8 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.

- The maximum detected total aluminum concentration was 45,100 µg/L in a sample from MW MW02D collected in November 2007.

Dissolved Aluminum

Below is a brief summary of groundwater sample results for dissolved aluminum in WBZ2.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL.
- The maximum detected total aluminum concentration was 23 µg/L in a sample from MW MW20 collected in December 2008.

For all but one sampling round, aluminum concentrations were below the Tap Water RSL for the WBZ2 MWs (Table 4.2.5-3). Because only one sample result exceeded the Tap Water RSL, no trends were noted for the WBZ2 groundwater aluminum results.

No plume contour maps were created for WBZ2 aluminum results because of the limited number of detections.

Total Antimony

The Tap Water RSL and MCL for antimony are 15 and 6 µg/L, respectively. Below is a brief summary of groundwater sample results for total antimony in WBZ2.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL.
- Samples from five MWs (38 percent) exceeded the MCL for at least one round of sampling.
- Samples from two MWs (15 percent) exceeded the Tap Water RSL or MCL value for every round of sampling.
- The maximum detected total antimony concentration was 14.5 µg/L in a sample from MW MW28 collected in September 2008.

Dissolved Antimony

Below is a brief summary of groundwater sample results for dissolved antimony in WBZ2.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL.
- Samples from none of the MWs (0 percent) exceeded the MCL.

- The maximum detected dissolved antimony concentration was 0.33 µg/L in a sample from MW MW05 collected in October 2009.

As mentioned in the fifth paragraph of [Section 4.2.5](#), the CRQL for antimony exceeded the Tap Water RSL and MCL. The exceedances described above for total antimony in WBZ2 groundwater all occurred during the same sampling round in September 2008 (Table 4.2.5-3). For all other sampling rounds, antimony concentrations were below the CRQL. Therefore, the results suggest an anomaly in which the laboratory detection limit was lower than the CRQL, and the antimony values are reported as detected values. All the September 2008 antimony results are flagged with a “J” to indicate that the value is estimated. For these reasons, graphs of the antimony exceedances over time were not created. Because all the antimony exceedances were for samples collected from the same sampling round (September 2008), no trends were noted in the WBZ2 groundwater antimony results. The only antimony exceedances occurred in September 2008 when the laboratory reported a detection limit that was less than the CRQL. Antimony in groundwater is not considered to be a COI and is not included in the WBZ2 summary below, nor it is included in the nature and extent summary in [Section 4.3](#). Antimony is included in the HHRA that is presented in Appendix RA.

No plume contour maps were created for WBZ2 antimony results because of the limited number of detections.

Total Cobalt

The Tap Water RSL for cobalt is 11 µg/L. There is no MCL for cobalt. Below is a brief summary of groundwater sample results for total cobalt in WBZ2.

- Samples from three MWs (23 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from one MW (8 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected total cobalt concentration was 49.5 µg/L in a sample from MW MW28 collected in September 2008.

Dissolved Cobalt

Below is a brief summary of groundwater sample results for dissolved cobalt in WBZ2.

- Samples from four MWs (31 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from one MW (8 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected dissolved cobalt concentration was 87.1 µg/L in a sample from MW MW13 collected in October 2009.

Generally, total and dissolved cobalt concentrations in the WBZ2 MWs exceeded the CRQL and were similar (Table 4.2.5-3 and Appendix S-36). When the samples were analyzed using the ICP-AES method in December 2008, the cobalt CRQL was 50 µg/L. Therefore, many sample results are reported as less than the CRQL. When the samples were analyzed using the ICP-mass spectroscopy method in June 2009, more sample results exceeded the CRQL. Turbidity does not appear to have affected cobalt concentrations.

Data for two MWs, MW02D, and MW23, suggest a trend of decreasing cobalt concentrations (Appendix S-36). The detected total and dissolved cobalt concentrations steadily decreased from November 2007 (or September 2008, depending well installation date) through October 2009. Data for MW MW13 suggest that the total and dissolved cobalt concentrations may be increasing.

Figures 4.2.5-21 and 4.2.5-22 show dissolved cobalt plumes for WBZ2 MWs based on December 2008 and June 2009 data, respectively. Figure 4.2.5-21 shows dissolved cobalt concentrations centered on the former main industrial area at OU2. Figure 4.2.5-22 shows an area of dissolved cobalt exceeding the MCL at MW13 on the eastern side of OU2.

Total Iron

The Tap Water RSL for iron is 26,000 µg/L. There is no MCL for iron. Below is a brief summary of groundwater sample results for total iron in WBZ2.

- Samples from one MW (8 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected total iron concentration was 46,700 µg/L in a sample from MW MW02D collected in November 2007.

Dissolved Iron

Below is a brief summary of groundwater sample results for dissolved iron in WBZ2.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected dissolved iron concentration was 3,540 µg/L in a sample from MW MW34 collected in December 2008.

Generally, iron concentrations exceeded the CRQL and the total and dissolved iron concentrations in the WBZ2 MWs were similar (Table 4.2.5-3 and Appendix S-36). Turbidity does not appear to have affected iron concentrations.

Data for MW MW02D suggest a trend of decreasing iron concentrations (Appendix S-36). At this location, the detected total and dissolved iron concentrations steadily decreased from November 2007 through October 2009. No other increasing or decreasing trends were evident based on WBZ2 groundwater iron results.

No plume contour maps were created for WBZ2 iron results because of the limited number of detections.

Total Manganese

The Tap Water RSL for manganese is 880 µg/L. There is no MCL for manganese. Below is a brief summary of groundwater sample results for total manganese in WBZ2.

- Samples from five MWs (38 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from four MWs (31 percent) exceeded the Tap Water RSL for every round of sampling.

The maximum detected total manganese concentration was 2,130 µg/L in a sample from MW MW23 collected in September 2008.

Dissolved Manganese

Below is a brief summary of groundwater sample results for dissolved manganese in WBZ2.

- Samples from three MWs (23 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from one MW (8 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected total manganese concentration was 3,380 µg/L in a sample from MW MW23 collected in March 2009.

Generally, total and dissolved manganese concentrations in the WBZ2 MWs exceeded the CRQL and were similar (Table 4.2.5-3 and Appendix S-36). Turbidity does not appear to have affected manganese concentrations.

Data for two MWs, MW02D and MW23, suggest a trend of decreasing manganese concentrations (Appendix S-36). At these MWs, the total and dissolved manganese concentrations steadily decreased from November 2007 (or September 2008, depending well installation date) through October 2009. Samples from MW MW18 had variable manganese concentrations that exceeded the CRQL and were at or exceeded the Tap Water RSL. However, no increasing or decreasing trend is evident.

Figures 4.2.5-25 and 4.2.5-26 show dissolved manganese plumes for WBZ2 MWs based on December 2008 and June 2009 data, respectively. Figure 4.2.5-25 shows three areas of dissolved manganese concentration that exceed the Tap Water RSL in the north-central, south, and east areas of the former main industrial area of OU2. Figure 4.2.5-26 shows one location, MW23, that exceeds the Tap Water RSL in the former main industrial area at OU2.

Total Thallium

The MCL for thallium is 2 µg/L. There is no Tap Water RSL for thallium. Below is a brief summary of groundwater sample results for total thallium in WBZ2.

- Samples from one MW (8 percent) exceeded the MCL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the MCL for every round of sampling.
- The maximum detected total thallium concentration was 6.2 µg/L in a sample from MW MW02D collected in November 2007.

Dissolved Thallium

Below is a brief summary of groundwater sample results for dissolved thallium in WBZ2.

- Samples from none of the MWs (0 percent) exceeded the MCL.
- The maximum detected total thallium concentration was 0.18 µg/L in a sample from MW MW23 collected in June 2009.

As mentioned in the fifth paragraph of [Section 4.2.5](#), the CRQL for thallium exceeded the MCL.

Thallium non-detected results for the WBZ2 samples frequently exceeded the MCL. However, the results did not exceed the CRQL and therefore are not considered to have exceeded the MCL. Thallium concentrations in one MW, MW02D, exceeded the MCL; however, this location did not yield multiple detections, so no increasing or decreasing trend is evident (Appendix S-36). Because few of the sample results exceeded the CRQL or the MCL, no trends were noted in the WBZ2 groundwater thallium results.

No plume contour maps were created for WBZ2 thallium results because of the limited number of detections.

Cyanide

Groundwater samples from the following rounds were analyzed for cyanide: November 2007 (select wells), March 2008 (all wells), June 2008 (all wells), September 2008 (all wells), December 2008 (Phase II wells only), March 2009 (Phase II wells only), and June 2009 (Phase II wells only). Table 4.2.5-1 summarizes the compounds analyzed for in each well during each sampling round. In Table 4.2.5-3, the groundwater metals results summary table, samples not analyzed for cyanide are marked as "--." Total and dissolved results for the WBZ2 groundwater samples analyzed for cyanide are summarized below. The Tap Water RSL and MCL for cyanide are 730 and 200 µg/L, respectively.

Total Cyanide

Below is a brief summary of groundwater sample results for total cyanide in WBZ2.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL.
- Samples from none of the MWs (0 percent) exceeded the MCL.
- The maximum detected dissolved total cyanide concentration was 5.8 µg/L in a sample from MW MW05 collected in March 2008.

Dissolved Cyanide

Below is a brief summary of groundwater sample results for dissolved cyanide in WBZ2.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL.
- Samples from none of the MWs (0 percent) exceeded the MCL.
- The maximum detected dissolved total cyanide concentration was 3.2 µg/L in a sample from MW MW19 collected in March 2009.

For all sampling rounds, cyanide concentrations were below the GWSVs for the WBZ2 groundwater results. Because cyanide concentrations did not exceed the GWSVs and few results exceeded the CRQL, no trend is evident for the WBZ2 groundwater cyanide results.

VOCs

All 13 WBZ2 MWs were sampled for VOCs. Table 4.2.5-4 summarizes the detected VOC results for WBZ1 and WBZ2 groundwater. Figure 4.2.5-27 shows the VOC results for both the WBZ1 and WBZ2 MWs that exceeded the MCLs and Tap Water RSLs. All VOC samples were unfiltered. Appendix S-37 presents the full set of groundwater VOC results. Figures 1 through 4 in Appendix S-38 show the VOC results for selected wells. WBZ2 groundwater results exceeded the Tap Water RSL or MCL values for the following VOCs: bromodichloromethane, chloroform, PCE, and TCE. Results for the individual VOC analytes are discussed below based on the number of Tap Water RSL and MCL exceedances.

Bromodichloromethane

The Tap Water RSL for bromodichloromethane is 0.12 µg/L. There is no MCL for bromodichloromethane. Below is a brief summary of groundwater sample results for bromodichloromethane in WBZ2.

- Samples from one MW (8 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected bromodichloromethane concentration was 0.15 µg/L in a sample from MW MW19 collected in December 2008.

Chloroform

The Tap Water RSL for chloroform is 0.19 µg/L. There is no MCL for chloroform. Below is a brief summary of groundwater sample results for chloroform in WBZ2.

- Samples from two MWs (15 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected chloroform concentration was 0.44 µg/L in a sample from MW MW22 collected in December 2008.

Tetrachloroethene

The Tap Water RSL and MCL for PCE are 0.11 µg/L and 5 µg/L, respectively. Below is a brief summary of groundwater sample results for PCE in WBZ2.

- Samples from one MW (8 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the MCL.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected PCE concentration was 0.57 µg/L in a sample from MW MW33 collected in June 2009.

Trichloroethene

The Tap Water RSL and MCL for TCE are 1.7 and 5 µg/L, respectively. Below is a brief summary of groundwater sample results for TCE in WBZ2.

- Samples from one MW (8 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the MCL.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected TCE concentration was 2.6 µg/L in a sample from well MW33 collected in September 2008.

VOCs were detected at concentrations at or exceeding the Tap Water RSLs for multiple analytes and sampling rounds in samples from three wells (MW19, MW22, MW33), which are screened in WBZ2 at OU2. MW33 is located near the former Rolling Mill building on the southern edge of OU2. The well

contained cVOCs at concentrations exceeding the Tap Water RSLs, particularly PCE and TCE, during multiple rounds of sampling (Figure 4.2.5-27 and Figure 4 in Appendix S-38). The highest cVOC concentration detected in MW33 was for TCE. Low concentrations of PCE also were detected in well MW33, but not at concentrations high enough to suggest a PCE release at this location. It is also possible that a PCE release occurred upgradient of MW33 in the past and the PCE has degraded primarily to TCE. Data suggest a decreasing trend for cVOC concentrations from September 2008 through October 2009. The cVOCs may be migrating laterally and vertically from WBZ1 MW04 and MW30, toward WBZ2 MW33.

SVOCs

All 13 WBZ2 MWs were sampled for SVOCs. Table 4.2.5-5 summarizes the detected SVOC results for WBZ1 and WBZ2 groundwater. No plume contour maps were created for WBZ1 or WBZ2 SVOC results because of the limited number of detections. All SVOC samples were unfiltered. Appendix S-39 presents the full set of groundwater SVOC results. WBZ2 groundwater results exceeded the Tap Water RSL or MCL values for the following PAH compounds: naphthalene. Results for the individual SVOC analytes are discussed below based on the number of Tap Water RSL and MCL exceedances.

Naphthalene

The Tap Water RSL for naphthalene is 0.14 µg/L. There is no MCL for naphthalene. Below is a brief summary of groundwater sample results for naphthalene in WBZ2.

- Samples from three MWs (23 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected naphthalene concentration was 1.5 µg/L in a sample from MW MW32 collected in September 2008.

SVOCs were detected at concentrations at or exceeding the Tap Water RSLs or MCLs at three WBZ2 MWs, MW22, MW32, and MW33. Sample results for MW22, MW32, and MW33 did not indicate any SVOCs detected during each round of sampling and did not exceed the Tap Water RSLs or MCLs for more than two rounds of sampling. No increasing or decreasing trends were evident for SVOCs in WBZ2 MWs.

PCBs

All 13 WBZ2 MWs were sampled for PCBs. Table 4.2.3-6 summarizes the detected PCB results for WBZ1 and WBZ2 groundwater. No plume contour maps were created for WBZ1 or WBZ2 PCB results because of the limited number of detections. All PCB samples were unfiltered. Appendix S-40 presents the full set of groundwater PCB results.

- None of samples contained PCBs at concentrations exceeding the CRQL of 1 µg/L.

Pesticides

All 13 WBZ2 MWs were sampled for pesticides. Table 4.2.5-7 summarizes the detected pesticide results for WBZ1 and WBZ2 groundwater. No plume contour maps were created for WBZ1 or WBZ2 pesticides results because of the limited number of detections. All pesticides samples were unfiltered. Appendix S-41 presents the full set of groundwater pesticides results. Results for the individual pesticides analytes are discussed below based on the number of Tap Water RSL and MCL exceedances.

Delta-BHC

The Tap Water RSL for delta-BHC is 0.011 µg/L. There is no MCL for delta-BHC. Below is a brief summary of groundwater sample results for delta-BHC in WBZ2.

- Samples from nine MWs (69 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL for every round of sampling.
- The maximum detected delta-BHC concentration was 0.03 µg/L in a sample from MW MW19 collected in October 2009.

Heptachlor Epoxide

The Tap Water RSL and MCL for heptachlor epoxide are 0.0074 and 0.2 µg/L, respectively. Below is a brief summary of groundwater sample results for heptachlor epoxide in WBZ2.

- Samples from four MWs (31 percent) exceeded the Tap Water RSL for at least one round of sampling.
- Samples from none of the MWs (0 percent) exceeded the MCL.

- Samples from none of the MWs (0 percent) exceeded the Tap Water RSL or MCL for every round of sampling.
- The maximum detected heptachlor epoxide concentration was 0.046 µg/L in a sample from MW MW28 collected in June 2009.

Pesticide compounds were detected at concentrations at or exceeding the Tap Water RSLs at ten WBZ2 MWs. None of the WBZ2 MWs have the same pesticide compound detected at concentrations exceeding the Tap Water RSLs during multiple rounds of sampling, nor was any compound detected during every round of sampling at a single well. Therefore, no increasing or decreasing trends were evident for pesticides in WBZ2 MWs.

OU2 WBZ2 Summary

Groundwater sample results for WBZ2 for OU2 reveal that concentrations of the following exceeded the GWSVs: total metals (arsenic, cadmium, lead, zinc, aluminum, cobalt, iron, manganese, and thallium), dissolved metals (arsenic, cadmium, lead, zinc, cobalt, and manganese), VOCs (bromodichloromethane, chloroform, PCE, and TCE), SVOCs (naphthalene), and pesticides (delta-BHC and heptachlor epoxide). As explained in [Section 4.2.5.1](#), in the antimony subsection, antimony is not considered a COI for nature and extent. The WBZ2 MWs are screened through the underlying fractured bedrock aquifer.

Groundwater contaminants in WBZ2 generally were less numerous and detected at lower concentrations than in WBZ1. Sample results for WBZ2 exceed the Tap Water RSLs or MCLs during multiple sampling rounds at MW02D, MW18, and MW33.

Metals (arsenic, cobalt, and manganese) sample results exceeded the GWSVs at greater than twenty-percent of WBZ2 sampling locations. MWs with metals concentrations exceeding the GWSVs of particular concern in WBZ2 include MW02D, MW18, and MW28. Sample results for these wells had the highest concentration for one or more metals. MW MW18 is located on the eastern edge of OU2 next to the LVR, and sample results exceeded cadmium and zinc GWSVs for all rounds of sampling.

SVOCs were detected at concentrations at or exceeding the GWSVs at three WBZ2 MWs; however, none of the locations indicate any SVOCs detected during each round of sampling and did not exceed the GWSVs for more than two rounds of sampling.

Sample results from WBZ1 and WBZ2 indicate a TCE release located on the northern side of the Rolling Mill building. The release likely has migrated laterally and vertically toward the WBZ2 MW MW33, which is located at the southeast corner of the Rolling Mill building.

PCBs were not detected above the CRQL in any WBZ2 MW.

Pesticides were detected at multiple WBZ2 MWs; however, the same pesticide compound was not detected at concentrations exceeding the GWSVs during every round of sampling at a single well.

Overall, the WBZ2 groundwater sample results indicate that contamination from historical operations has percolated into the subsurface bedrock aquifer.

4.2.6 OU2 Surface Water Results

Surface water samples were collected during both Phase I and Phase II field investigations. SulTRAC collected 23 samples (excluding field duplicates and QC samples) from 11 distinct surface water locations across OU2. The samples were collected from intermittent and ephemeral streams, drainage or sewer lines, and areas of standing water at OU2. Figure 4.2.6-1 shows the surface water sampling locations. Four separate surface water sampling events were conducted during the RI, two during Phase I and two during Phase II. The first sampling event occurred on July 24, 2007, when SulTRAC collected surface water samples during “dry” weather conditions. The second set of surface water samples were collected on August 8 and 15, 2007, during “wet” weather conditions during a rain event. The third event was conducted on July 8, 2008. The fourth event took 2 days to complete and was conducted on October 30 and November 3, 2008. The goal of the two Phase I sampling events was to evaluate the effects of variations in precipitation. The goal of the Phase II sampling events was to evaluate the effects of seasonal variations.

SulTRAC conducted the Phase I investigation during two rounds in Summer 2007 and collected a total of 13 surface water samples from seven locations. Seven samples were collected during the “dry” event (July 2007), and six of these locations were resampled during the “wet” event (August 2007). Location SW001 contained no standing water in August 2007, so that location could not be resampled. SulTRAC conducted the Phase II investigation during two rounds Summer and Fall 2008 and collected a total of 10 surface water samples from five locations. Phase II surface water samples were collected from different locations than the Phase I samples except for two surface water locations that were sampled during both the Phase I and Phase II investigations. Phase I location SW005 was sampled again during Phase II (sample identification SW012). Phase I location SW007 was sampled again during Phase II (sample identification SW013). Additionally, US EPA requested sampling of an additional location in the northern portion of the main industrial area in a recessed rectangular foundation where a former lead-lined acid tank was present (SW018). This location was sampled during the October/November 2008

sampling event. Table 4.2.6-1 summarizes the locations sampled during each phase (Phase I or Phase II) and sampling event.

Phase I surface water samples were collected from the following locations:

- Three locations where flowing ephemeral or intermittent streams were present (SW001, SW003, and SW004)
- One location in a standing body of water from a basin containing an AST (SW002)
- One location each from the source (SW005, collocated with SW012), middle (SW006), and mouth (SW007, collocated with SW013) of the stream that flows from the abandoned sewer line into the LVR

The Phase II surface water sampling locations included:

- The source (SW012, collocated with SW005) and mouth (SW013, collocated with SW007) of the stream emanating from the abandoned sewer line and emptying into the LVR
- One location in the north area where standing water in a wetlands-type area often was observed (SW014)
- One location of discharge from the main industrial plant area (SW011);
- One location where standing water was often observed in the main industrial area (SW010)
- The US EPA-requested sampling location in the northern portion of the main industrial area from the foundation where the former lead-lined acid tank was present (SW018)

Locations SW001, SW003, SW004, and SW011 are all located from the mouth or along the same intermittent stream in the former main industrial area at OU2. Locations SW005/SW012, SW006, and SW007/SW013 are all located along the stream emanating from the abandoned sewer line and emptying into the LVR.

All samples were analyzed for total (unfiltered metals) and cyanide, VOCs, SVOCs, PCBs, and pesticides. In addition, samples from the last sampling round, October/November 2008, also were analyzed for total hardness and dissolved (filtered) metals as requested by US EPA. Samples were analyzed for these analytical groups using appropriate US EPA methods as listed in Table 2.2.1-3 in [Section 2.0](#). In addition, QC samples (field duplicate, trip blank, MS, and MS/MSD samples) were collected for surface water samples as described in the SAP (SulTRAC 2008a). All surface water sample identification numbers have the prefix “SW” before the three-digit sampling location number.

Tables 4.2.6-2 through 4.2.6-5 summarize the detected metals, VOC, SVOC, and pesticide analytical results, respectively. No summary table was created for PCBs since all PCB congener concentrations were less than the CRQLs. Appendices S-42 through S-46 summarize all surface water results for metals, VOC, SVOC, PCB, and pesticide analytical results, respectively. The surface water sample results were compared to the surface water screening values (SWSVs). The SWSVs are based upon the human health surface water medium-specific screening criteria agreed upon and presented in Attachment 4, Revision 1, of the Consensus Document (Appendix RA-1). These SWSVs represent the most conservative of the following:

- IWQS values based on general use and the protection of human health
- IEPA-derived Water Quality Criteria for Human Health
- NRWQC for ingestion of aquatic organisms

If a value was not available from any of the sources listed above, the US EPA Tap Water RSLs were used.

The SWSVs are not divided by a factor of 10 (indicating the non-cancer hazard quotient [HQ]) as they were for the HHRA.

It should be noted that for certain analytes, the CLP CRQL for low-concentration surface water analysis exceeded the SWSVs and these results are flagged as non-detects. The CRQLs for arsenic, cobalt, mercury, silver, and thallium exceed SWSV. If the CRQL exceeded the SWSV, results listed as non-detect do not guarantee that the contaminant concentration is less than the SWSV. Each of these contaminants is discussed further in the respective sections below.

The following sections summarize OU2 surface water metals and cyanide, VOC, SVOC, PCB, and pesticides results, followed by a surface water summary for OU2. Because of the limited number of SWSV exceedances, the VOC, SVOC, PCB, and pesticides results are not presented in figures.

4.2.6.1 Metals and Cyanide

All 11 OU2 surface water locations were sampled at least once for metals and cyanide. Eight of the surface water locations were sampled at least twice for metals and cyanide. A total of 28 discrete surface water samples, excluding field duplicate samples, were submitted for metals analysis. Samples from five of the locations were field filtered during the October/November 2008 event, and these five locations have one dissolved and one total sample result for the October/November 2008 event. The remaining 23

of the 28 samples were analyzed for total metals. The dissolved and total metals samples are discussed separately below. Table 4.2.6-2 summarizes the detected metals results.

Appendix S-42 presents the full set of surface water metals results. Figures 4.2.6-1 through 4.2.6-7 show the RI surface water sampling locations and metals results. The higher of the sample duplicate or original sample result was used in the figures and are discussed below.

Arsenic

Samples from all 11 OU2 surface water sampling locations were analyzed for arsenic (Figure 4.2.6-2). The SWSV for arsenic is 0.14 µg/L, which is the NRWQC value.

Total Arsenic

Below is a brief summary of surface water sample results for total arsenic in OU2.

- Samples from nine surface water locations (82 percent) exceeded the SWSV for at least one round of sampling.
- Samples from two surface water locations (22 percent) exceeded the SWSV for every round of sampling.
- The maximum detected total arsenic concentration was 11.1 µg/L in a sample from SW007 collected in July 2007.

Dissolved Arsenic

Below is a brief summary of surface water sample results for dissolved arsenic in OU2.

- Samples from one surface water location (20 percent) exceeded the SWSV for at least one round of sampling.
- Samples from one surface water location (20 percent) exceeded the SWSV for every round of sampling.
- The maximum detected dissolved arsenic concentration was 10.1 µg/L in a sample from SW018 collected in October/November 2008.

Arsenic concentrations exceeded the SWSV at most sampling locations for at least one sampling round. Eight of the eleven sampling locations were sampled at least twice for arsenic. Because the CRQL for arsenic (10 µg/L) exceeded the SWSV (0.14 µg/L), many of the arsenic results are listed as below the

detection limit and therefore could not be compared to the SWSV. None of the sample results for the eight locations exceeded the CRQL for more than one sampling round.

Cadmium

Samples from all 11 OU2 surface water sampling locations were analyzed for cadmium (Figure 4.2.6-3). The SWSV for cadmium is 18 µg/L, which is the US EPA Tap Water RSL.

Total Cadmium

Below is a brief summary of surface water sample results for total cadmium in OU2.

- Samples from nine surface water locations (82 percent) exceeded the SWSV for at least one round of sampling.
- Samples from nine surface water locations (82 percent) exceeded the SWSV for every round of sampling.
- The maximum detected total cadmium concentration was 1,550 µg/L in a sample from SW011 collected in July 2008.

Dissolved Cadmium

Below is a brief summary of surface water sample results for dissolved cadmium in OU2.

- Samples from four surface water locations (80 percent) exceeded the SWSV for at least one round of sampling.
- Samples from four surface water locations (80 percent) exceeded the SWSV for every round of sampling.
- The maximum detected dissolved cadmium concentration was 1,320 µg/L in a sample from SW011 (field duplicate sample) collected in October/November 2008.

Cadmium concentrations exceeded the SWSV at most sampling locations for every round of sampling.

Lead

Samples from all 11 OU2 surface water sampling locations were analyzed for lead (Figure 4.2.6-4). The SWSV for lead is 15 µg/L, which is the US EPA Tap Water RSL.

Total Lead

Below is a brief summary of surface water sample results for total lead in OU2.

- Samples from 10 surface water locations (91 percent) exceeded the SWSV for at least one round of sampling.
- Samples from nine surface water locations (82 percent) exceeded the SWSV for every round of sampling.
- The maximum detected total lead concentration was 1,420 µg/L in a sample from SW018 collected in October/November 2008.

Dissolved Lead

Below is a brief summary of surface water sample results for dissolved lead in OU2.

- Samples from four surface water locations (80 percent) exceeded the SWSV for at least one round of sampling.
- Samples from four surface water locations (80 percent) exceeded the SWSV for every round of sampling.
- The maximum detected dissolved lead concentration was 1,410 µg/L in a sample from SW018 collected in October/November 2008.

Lead concentrations exceeded the SWSV at most sampling locations. Sample results for all but one location exceeded the SWSV for every round of sampling. The maximum detected total and dissolved lead concentrations were detected at SW018, which the location of a tank that formerly stored sulfuric acid. The pH of the surface water at SW018 was 2.11 standard units (SU) in March 2009, which suggests that all metals are present only in the dissolved phase. Additionally, turbidity affects lead concentrations in surface water. The filtered lead concentrations were lower than the total lead concentrations for all samples.

Mercury

Samples from 10 OU2 surface water sampling locations were analyzed for mercury (Figure 4.2.6-5). Surface water sampling location SW001 did not yield an adequate sample volume for mercury analysis. The SWSV for mercury is 0.012 µg/L, which is the IWQS value.

Total Mercury

Below is a brief summary of surface water sample results for total mercury in OU2.

- Samples from seven surface water locations (70 percent) exceeded the SWSV for at least one round of sampling.
- Samples from two surface water locations (20 percent) exceeded the SWSV for every round of sampling.
- The maximum detected total mercury concentration was 2.3 µg/L in a sample from SW004W (wet weather sample) collected in August 2007.

Dissolved Mercury

Below is a brief summary of surface water sample results for dissolved mercury in OU2.

- Samples from none of the surface water locations (0 percent) exceeded the SWSV.
- All surface water sample results for dissolved mercury were less than the CRQL of 0.2 µg/L.

Mercury concentrations exceeded the SWSV at most sampling locations for at least one sampling round. Eight of the ten sampling locations were sampled at least twice for mercury. Because the CRQL for mercury (0.2 µg/L) exceeded the SWSV (0.012 µg/L), many of the mercury results are listed as below the detection limit and therefore could not be compared to the SWSV. None of sample results for the eight locations exceeded the CRQL for more than one sampling round.

Zinc

Samples from all 11 OU2 surface water sampling locations were analyzed for zinc (Figure 4.2.6-6). The SWSV for zinc is 26,000 µg/L, which is the NRWQC value.

Total Zinc

Below is a brief summary of surface water sample results for total zinc in OU2.

- Samples from eight surface water locations (73 percent) exceeded the SWSV for at least one round of sampling.
- Samples from eight surface water locations (73 percent) exceeded the SWSV for every round of sampling.

- The maximum detected total zinc concentration was 276,000 µg/L in a sample from SW011 collected in October/November 2008.

Dissolved Zinc

Below is a brief summary of surface water sample results for dissolved zinc in OU2.

- Samples from four surface water locations (80 percent) exceeded the SWSV for at least on round of sampling.
- Samples from four surface water locations (80 percent) exceeded the SWSV for every round of sampling.
- The maximum detected dissolved zinc concentration was 275,000 µg/L in a sample from SW011 collected in October/November 2008.

Zinc concentrations exceeded the SWSV at most sampling locations for every round of sampling.

Other Metals

“Other metals” are a secondary group comprising metals detected more often than not in the surface water samples. However, the spatial extents of these detected metals are not as great or the metal is not as potentially harmful as the metals individually discussed above (arsenic, cadmium, lead, mercury, and zinc). “Other metals” does not include the metals individually discussed above or the nutrient metals that do not have exceedance criteria (calcium, magnesium, potassium, and sodium). The secondary group of metals includes aluminum, antimony, barium, chromium, cobalt, copper, iron, manganese, nickel, selenium, thallium, and vanadium.

Samples from all 11 surface water sampling locations were analyzed for other metals. Table 4.2.6-2 summarizes the detected other metals results for the surface water samples. Figure 4.2.6-7 shows the surface water sampling locations and other metals results. Surface water sample results exceeded the SWSVs for the following compounds: cobalt, iron, manganese, silver, and thallium. SWSVs and total and dissolved results for each metal are summarized below.

Total Cobalt

The SWSV for cobalt is 11 µg/L, which is the US EPA Tap Water RSL. Below is a brief summary of surface water sample results for total cobalt in OU2.

- Samples from four surface water locations (36 percent) exceeded the SWSV for at least one round of sampling.
- Samples from three surface water locations (27 percent) exceeded the SWSV for every round of sampling.
- The maximum detected total cobalt concentration was 15.5 µg/L in a sample from SW011 collected in October/November 2008.

Dissolved Cobalt

Below is a brief summary of surface water sample results for dissolved cobalt in OU2.

- Samples from none of the surface water locations (0 percent) exceeded the SWSV.
- All surface water sample results for dissolved cobalt were less than the CRQL of 50 µg/L.

Cobalt concentrations exceeded the SWSV at most sampling locations for at least one sampling round. Eight of the eleven sampling locations were sampled at least twice for cobalt. Because the CRQL (50 µg/L) for cobalt exceeded the SWSV (11 µg/L), many of the cobalt results are listed as below the detection limit and therefore could not be compared to the SWSV. Sample results for three of the eight locations exceeded the CRQL and SWSV for more than one sampling round.

Total Iron

The SWSV for iron is 1,000 µg/L, which is the IWQS value. Below is a brief summary of surface water sample results for total iron in OU2.

- Samples from six surface water locations (55 percent) exceeded the SWSV for at least one round of sampling.
- Samples from two surface water locations (18 percent) exceeded the SWSV for every round of sampling.
- The maximum detected total iron concentration was 31,700 µg/L in a sample from SW018 collected in October/November 2008.

Dissolved Iron

Below is a brief summary of surface water sample results for dissolved iron in OU2.

- Samples from one surface water location (8 percent) exceeded the SWSV for at least one round of sampling.
- Samples from one surface water location (8 percent) exceeded the SWSV for every round of sampling.
- The maximum detected dissolved iron concentration was 31,700 µg/L in a sample from SW018 collected in October/November 2008.

Iron concentrations exceeded the SWSV at most locations. The maximum detected total and dissolved iron concentrations were for samples collected from SW018, which is where a tank formerly stored sulfuric acid. The pH at SW018 was 2.11 SU in March 2009, which suggests that all metals are present only in the dissolved phase.

Total Manganese

The SWSV for manganese is 1,000 µg/L, which is the IWQS value. Below is a brief summary of surface water sample results for total manganese in OU2.

- Samples from one surface water location (9 percent) exceeded the SWSV for at least one round of sampling.
- Samples from one surface water location (9 percent) exceeded the SWSV for every round of sampling
- The maximum detected total manganese concentration was 1,210 µg/L in a sample from SW018 collected in October/November 2008.

Dissolved Manganese

Below is a brief summary of surface water sample results for dissolved manganese in OU2.

- Samples from one surface water location (8 percent) exceeded the SWSV for at least one round of sampling.
- Samples from one surface water location (8 percent) exceeded the SWSV for every round of sampling.
- The maximum detected dissolved manganese concentration was 1,210 µg/L in a sample from SW018 collected in October/November 2008.

Sample results for one round at one sampling location exceeded the SWSV for manganese. The maximum detected total and dissolved manganese concentrations were for samples collected from SW018, which is where a tank formerly stored sulfuric acid. The pH at SW018 was 2.11 SU in March 2009, which suggests that all metals are present only in the dissolved phase. Manganese concentrations tended to exceed the CRQL of 16.7 µg/L and be below the SWSV of 1,000 µg/L.

Total Silver

The SWSV for silver is 5 µg/L, which is the IWQS value. Below is a brief summary of surface water sample results for total silver in OU2.

- Samples from three surface water locations (27 percent) exceeded the SWSV for at least one round of sampling.
- Samples from none of the surface water locations (0 percent) exceeded the SWSV for every round of sampling.
- The maximum detected total silver concentration was 10 µg/L in a sample from SW007 collected in July 2007.

Dissolved Silver

Below is a brief summary of surface water sample results for dissolved silver in OU2.

- Samples from none of the surface water locations (0 percent) exceeded the SWSV.
- All surface water sample results for dissolved silver were less than the CRQL of 11.1 µg/L.

Samples from two sampling locations exceeded the SWSV for silver. Because the CRQL (10 µg/L) for silver exceeded the SWSV (5 µg/L), many of the silver results are listed as at or below the detection limit and therefore could not be compared to the SWSV. Silver results for a few samples were less than the CRQL of 10 µg/L and less than the SWSV of 5 µg/L.

Total Thallium

The SWSV for thallium is 0.47 µg/L, which is the NRWQC value. Below is a brief summary of surface water sample results for total thallium in OU2.

- Samples from one surface water location (9 percent) exceeded the SWSV for at least one round of sampling.

- Samples from none of the surface water locations (0 percent) exceeded the SWSV for every round of sampling.
- The maximum detected total thallium concentration was 4.1 µg/L in a sample from SW011 collected in July 2008.

Dissolved Thallium

Below is a brief summary of surface water sample results for dissolved thallium in OU2.

- Samples from none of the surface water locations (0 percent) exceeded the SWSV.
- All surface water sample results for dissolved thallium were less than the CRQL of 27.8 µg/L.

Sample results for one round at one sampling location exceeded the SWSV for thallium. Because the CRQL (25 µg/L) for thallium exceeded the SWSV (0.47 µg/L), many of the thallium results are listed as below the detection limit and therefore could not be compared to the SWSV.

Cyanide

Groundwater samples from the following rounds and locations were sampled and analyzed for cyanide: August 2007 (Phase I locations only), July 2008 (Phase II locations only), and October/November 2008 (Phase II locations only). All cyanide samples were unfiltered and analyzed for total cyanide. Samples not analyzed for cyanide are marked as “NA” in the metals results table (Appendix D-22). There is no SWSV for cyanide.

- All surface water sample results for cyanide were less than the CRQL of 10 µg/L.

OU2 Metals Summary

All surface water samples collected were analyzed for total metals. Samples collected from the Phase II locations in October/November 2008 were analyzed for total and dissolved metals. For the Phase I surface water sampling event, samples collected from SW003 and SW004 typically yielded the maximum detected concentrations and concentrations exceeding the SWSVs. SW003 and SW004 are located in the former main industrial area. For the Phase II surface water sampling event, samples collected from SW011 and SW018 yielded the maximum detected concentrations and concentrations exceeding the SWSVs. The surface water sample at SW011 was collected from a manmade discharge wall located in the former main industrial area. The sample at SW018 was collected from the southeastern rectangular

acid bath located in the former main industrial area. The pH at SW018 was very low (2.11 SU) in March 2009, suggesting that all metals are present only in the dissolved phase.

4.2.6.2 VOCs

All 11 OU2 surface water sampling locations were sampled for VOCs (Table 4.2.6-1). Table 4.2.6-3 summarizes the detected VOC results for OU2 surface water. All VOC samples were unfiltered. Appendix S-43 presents the full set of surface water VOC results.

- Samples from none of the surface water locations (0 percent) exceeded the SWSVs.

4.2.6.3 SVOCs

All 11 OU2 surface water sampling locations were sampled for SVOCs (Table 4.2.6-1). Table 4.2.6-4 summarizes the detected SVOC results for OU2 surface water samples. All SVOC samples were unfiltered. Appendix S-44 presents the full set of surface water SVOC results. OU2 surface water results exceeded the SWSVs for bis(2-ethylhexyl)phthalate. The SWSV and results for bis(2-ethylhexyl)phthalate are summarized below.

Bis(2-ethylhexyl)phthalate

The SWSV for bis(2-ethylhexyl)phthalate is 1.9 µg/L, which is the IEPA-derived Water Quality Criteria for Human Health value. Below is a brief summary of surface water sample results for bis(2-ethylhexyl)phthalate in OU2.

- Samples from one surface water location (9 percent) exceeded the SWSV for at least one round of sampling.
- Samples from one surface water location (9 percent) exceeded the SWSV for every round of sampling.
- The maximum detected bis(2-ethylhexyl)phthalate concentration was 2.3 µg/L in a sample from SW002W collected in August 2007.

4.2.6.4 PCBs

All 11 OU2 surface water sampling locations were sampled for PCBs (Table 4.2.6-1). All PCB samples were unfiltered. Appendix S-45 presents the full set of surface water PCB results.

- PCBs were not detected in any of the OU2 surface water samples at concentrations exceeding the CRQL of 1.0 µg/L.

4.2.6.5 Pesticides

All 11 OU2 surface water sampling locations were sampled for pesticides (Table 4.2.6-1). Table 4.2.3-5 summarizes the detected pesticides results for OU2 surface water samples. All pesticides samples were unfiltered. Appendix S-46 presents the full set of surface water pesticides results. OU2 surface water results exceeded the SWSVs for the following compounds: alpha-BHC, alpha-chlordane, beta-BHC, delta-BHC, dieldrin, heptachlor, and heptachlor epoxide. SWSVs and results for each pesticide are summarized below.

Alpha-BHC

The SWSV for alpha-BHC is 0.0042 µg/L, which is the IEPA-derived Water Quality Criteria for Human Health value. Below is a brief summary of surface water sample results for alpha-BHC in OU2.

- Samples from one surface water location (9 percent) exceeded the SWSV for at least one round of sampling.
- Samples from one surface water location (9 percent) exceeded the SWSV for every round of sampling.
- The maximum detected alpha-BHC concentration was 0.013 µg/L in a sample from SW018 collected in October/November 2008.

Alpha-Chlordane

The SWSV for alpha-chlordane is 0.00072 µg/L, which is the IEPA-derived Water Quality Criteria for Human Health value. Below is a brief summary of surface water sample results for alpha-chlordane in OU2.

- Samples from one surface water location (9 percent) exceeded the SWSV for at least one round of sampling.
- Samples from none of the surface water locations (0 percent) exceeded the SWSV for every round of sampling.
- The maximum detected alpha-chlordane concentration was 0.0017 µg/L in a sample from SW011 (field duplicate sample) collected in October/November 2008.

Beta-BHC

The SWSV for beta-BHC is 0.015 µg/L, which is the IEPA-derived Water Quality Criteria for Human Health value. Below is a brief summary of surface water sample results for beta-BHC in OU2.

- Samples from one surface water location (9 percent) exceeded the SWSV for at least one round of sampling.
- Samples from one surface water location (9 percent) exceeded the SWSV for every round of sampling.
- The maximum detected beta-BHC concentration was 0.042 µg/L in a sample from SW018 collected in October/November 2008.

Delta-BHC

The SWSV for delta-BHC is 0.0049 µg/L, which is the NRWQC value. Below is a brief summary of surface water sample results for delta-BHC in OU2.

- Samples from one surface water location (9 percent) exceeded the SWSV for at least one round of sampling.
- Samples from none of the surface water locations (0 percent) exceeded the SWSV for every round of sampling.
- The maximum detected delta-BHC concentration was 0.013 µg/L in a sample from SW002W collected in August 2007.

Dieldrin

The SWSV for dieldrin is 0.000046 µg/L, which is the IEPA-derived Water Quality Criteria for Human Health value. Below is a brief summary of surface water sample results for dieldrin in OU2.

- Samples from one surface water location (9 percent) exceeded the SWSV for at least one round of sampling.
- Samples from none of the surface water locations (0 percent) exceeded the SWSV for every round of sampling.
- The maximum detected dieldrin concentration was 0.0031 µg/L in a sample from SW014 collected in October/November 2008.

Heptachlor

The SWSV for heptachlor is 0.000068 µg/L, which is the NRWQC value. Below is a brief summary of surface water sample results for heptachlor in OU2.

- Samples from two surface water locations (18 percent) exceeded the SWSV for at least one round of sampling.
- Samples from none of the surface water locations (0 percent) exceeded the SWSV for every round of sampling.
- The maximum detected heptachlor concentration was 0.044 µg/L in a sample from SW018 collected in October/November 2008.

Heptachlor Epoxide

The SWSV for heptachlor epoxide is 0.000036 µg/L, which is the IEPA-derived Water Quality Criteria for Human Health value. Below is a brief summary of surface water sample results for heptachlor epoxide in OU2.

- Samples from one surface water location (8 percent) exceeded the SWSV for at least one round of sampling.
- Samples from none of the surface water locations (0 percent) exceeded the SWSV for every round of sampling.
- The maximum detected heptachlor epoxide concentration was 0.0063 µg/L in a sample from SW003W collected in August 2007.

4.2.6.6 OU2 Surface Water Summary

Surface water sample results for OU2 reveal that concentrations of the following exceeded the SWSVs: total metals (arsenic, cadmium, lead, mercury, zinc, cobalt, iron, manganese, silver, and thallium), dissolved metals (arsenic, cadmium, lead, zinc, iron, and manganese), bis(2-ethylhexyl)phthalate, and pesticides (alpha-BHC, alpha-chlordane, beta-BHC, delta-BHC, dieldrin, heptachlor, and heptachlor epoxide).

4.2.7 OU2 Air Results

Two asbestos air sampling events were conducted to assess exposure and risks associated with asbestos inhalation at OU2: passive sampling was conducted on July 9 2008, and ABS was conducted on

September 30, 2009. In 2008, passive air samples from four sampling locations were collected. In 2009 samples were collected from, four ABS sampling locations (two samples from each location), four perimeter sampling locations, and one background sampling location. Table 2.2.8-1 and Figure 2.2.8-1 summarize the samples collected and show the sampling locations.

During the passive sampling event conducted on July 9, 2008, SulTRAC collected four passive ambient air samples (AbsAir1 through AbsAir4) from four sampling locations at OU2 before the commencement of intrusive sampling activities (such as the installation of soil borings and wells). Two samples (AbsAir1 and AbsAir2) were collected from the former main industrial area, and the other two samples (AbsAir3 and AbsAir4) were collected from inside the former Rolling Mill building. High-volume Eberline sampling pumps powered by a gas generator were used to collect air samples from the former main industrial area, and low-volume Gillian pumps were used to collect air samples from inside the former Rolling Mill building. Table 2.2.8-1 summarizes the flow rates, pump start and stop times, and sample volumes for the passive sampling event.

Asbestos fibers were detected in soil borings and pile and building material samples collected from OU2, resulting in a second asbestos air sampling event in September 2009. The purposes of this event were to evaluate risks to workers from asbestos in air during invasive soil activities and to evaluate whether invasive activities released any asbestos fibers. SulTRAC chose two locations to perform ABS, set up four perimeter air sampling locations along the perimeter of OU2, and set up one background air sampling location off-site on the LaSalle Fire Department property. In addition, US EPA set up four RAFS units at OU2 (Figure 2.2.8-1).

The ABS and RAFS sampling event at OU2 was conducted on September 30, 2009. Air samples were collected from the four outdoor locations where analytical results showed approximately 1 percent of asbestos fibers in surface soil samples collected during Phase I surface soil sampling activities. SulTRAC performed the ABS sampling, and US EPA operated the RAFS units. [Section 2.2.8](#) presents a detailed discussion of the ABS and RAFS sampling methods.

On September 30, 2009, SulTRAC performed ABS at two locations: west of Building 100 (AbsAir6) and west of the Pump House (AbsAir8). US EPA collected samples from RAFS units at four locations: the southwestern area of the furnaces (RAFS-A5), west of Building 100 (RAFS-A6), the former main industrial area (RAFS-A7), and west of the Pump House (RAFS-A8). Two samples were collected at each of the ABS sampling locations. ABS and RAFS locations AbsAir6 and RAFS-A6, and AbsAir8 and RAFS-A8 are collocated. Sampling locations were limited to areas of known asbestos soil contamination

near the 1 percent concentration threshold in accordance with the US EPA asbestos guidance (US EPA 2008c). Areas with asbestos concentrations much greater than the 1 percent threshold where human exposure risks are expected and assumed to be highest were not proposed for ABS or RAFS sampling.

The generic ABS scenario (raking) described in the US EPA *Emergency Response Team's (ERT) SOP entitled "Activity-Based Air Sampling for Asbestos" dated May 10, 2007* (Appendix S-2) was followed in order to evaluate asbestos fiber releases from the soil. Each cycle of raking and rotating continued for approximately 100 minutes. A total of four field samples (two samples from each location) were collected using the ABS raking scenario and submitted to the laboratory for asbestos analysis. The air samples were collected using personal air sampling equipment to reflect the concentration of asbestos in the breathing zone. The breathing zone was defined as a hemisphere of approximately 6 to 9 inches around an individual's face (US EPA 2008c).

The RAFS unit was used in conjunction with ABS sampling because the RAFS unit aerosolizes asbestos fibers in a small enclosed area, minimizing the spread of asbestos fibers from surface soil. Additionally, the time it takes to collect samples using the RAFS unit was minimal, reducing the labor and funding needed for sampling activities. Asbestos air samples were collected using the RAFS unit before the ABS air samples were collected from locations AbsAir6 and AbsAir8 because the RAFS method does not disturb soil as much as the ABS method. US EPA used the analytical data from the RAFS units to develop a model that predicts asbestos fiber transport to a person's breathing zone in order to derive an inhalation concentration for human receptors. Table 4.2.7-1 summarizes the asbestos air results for OU2 and presents the raw field RAFS data. However, these data are not included in the OU2 investigation area summaries below because RAFS data are not representative of breathing zone concentrations. The OU2 HHRA discussion in [Section 7.2](#) summarizes the RAFS data results, US EPA's RAFS model, and effects on human health.

Concurrent with the generic ABS and RAFS activities, one background air sample from location B1 and four perimeter air samples from PS1 through PS4 were collected (Table 4.2.7-1 and Figure 2.2.8-1). The background sample was collected from the LaSalle Fire Department approximately 0.5 mile south of the southernmost boundary of OU2.

All samples collected during the ABS and RAFS sampling activities were submitted to a subcontracted laboratory capable of analyzing the samples in accordance with the ISO Method 10312, "Ambient air – Determination of asbestos fibers – Direct-transfer TEM." Table 4.2.7-1 presents the asbestos analytical results for each sample. Air samples were analyzed for asbestos only.

The following sections summarize air asbestos results for Investigation Areas 1, 2, and 3.

4.2.7.1 Investigation Area 1: Building 100

A total of three asbestos air samples were collected from two sampling locations (AbsAir6 and PS2) near Building 100. One set of ABS samples and one perimeter sample were collected in September 2009. Air asbestos results are summarized below. Table 4.2.7-1 summarizes the asbestos air sample results. Figure 2.2.8-1 shows the OU2 asbestos air sampling locations.

Asbestos

All three Investigation Area 3 asbestos air samples were analyzed for asbestos and are summarized in Table 4.2.7-1.

- None of the sample results (0 percent) tested positive for asbestos above the detection limit, which ranged from 0.005 to 0.006 fiber per cubic centimeter (f/cc).

4.2.7.2 Investigation Area 2: Rolling Mill

Two asbestos air samples were collected from two sampling locations (AbsAir3 and AbsAir4) inside the Rolling Mill in July 2008, and one perimeter air sample (PS4) was located near the southeast corner of the Rolling Mill building in September 2009. Asbestos air results are summarized below. Table 4.2.7-1 summarizes the asbestos air sample results. Figure 2.2.8-1 shows the OU2 asbestos air sampling locations.

Asbestos

All three Investigation Area 2 asbestos air samples collected were analyzed for asbestos.

- None of the sample results (0 percent) tested positive for asbestos above the detection limit, which ranged from 0.005 to 0.006 f/cc.

4.2.7.3 Investigation Area 3: Former Main Industrial Area

A total of six asbestos air samples were collected from five sampling locations (AbsAir1, AbsAir2, AbsAir8, PS1, and PS3) in the former main industrial area. Two passive air samples (AbsAir 1 and Abs2) were collected in July 2008, two ABS samples (AbsAir8) were collected in September 2009, and two perimeter samples (PS1 and PS3) were collected in September 2009. Air asbestos results are

summarized below. Table 4.2.7-1 summarizes the asbestos air sample results. Figure 2.2.8-1 shows the OU2 asbestos air sampling locations.

Asbestos

All six Investigation Area 3 asbestos air samples were analyzed for asbestos and are summarized in Table 4.2.7-1.

- None of the sample results (0 percent) tested positive for asbestos above the detection limit, which ranged from 0.005 to 0.006 f/cc.

4.3 SITE-WIDE INTERPRETATION OF RI RESULTS

The following sections summarize the interpretations of results for soil, groundwater, sediment, and surface water for OU1 ([Section 4.3.1](#)) and for soil/solid, groundwater, surface water, and air samples for OU2 ([Section 4.3.2](#)). [Section 4.3.3](#) discusses the site-wide synthesis of soil and groundwater data collected between OU1 and OU2. Specifically, [Section 4.3.3.1](#) presents an interpretation of the soil results in border areas straddling OU1 and OU2, and [Section 4.3.3.2](#) discusses groundwater results that impact both OU1 and OU2.

4.3.1 OU1

This section discusses the OU1 soil/solid, groundwater, surface water, and sediment results. The soil and slag results are summarized together in [Section 4.3.1.1](#) under the soil results. [Section 4.3.1.2](#) summarizes the groundwater results. Surface water and sediment are discussed under [Section 4.3.1.3](#).

Table 4.3.1-1 summarizes contaminants detected at concentrations exceeding the SVs in more than one sample per medium (soil, slag, groundwater, surface water, and sediment). Table 4.3.1-1 shows that measured metals concentrations were above SVs in samples collected from all media in OU1 (i.e., soil, sediment, groundwater, and surface water). With the exception of acetone measured in sediment samples, measured concentrations of VOCs were above SVs only in one groundwater sample from the Plant Area in OU1. Measured concentrations of SVOCs were above SVs in one groundwater sample from the Plant Area (collected from G-106 on 11/1/1991), shallow and deep soil samples, and sediment samples from OU1. Measured concentrations of PCBs were above SVs in shallow soil samples from the Plant Area, and sediment samples from OU1.

4.3.1.1 OU1 Soil Results

As discussed in [Section 4.1.2](#), measured concentrations of several metals, SVOCs, and two PCBs were above RRSs and/or IRSs in soil samples from the Slag Pile and Plant Areas (Tables 4.1.2-3, 4.1.2-4, 4.1.2-15, and 4.1.2-16).

Metals are widespread in soil samples collected from OU1. Several metals were present at concentrations above SVs in both shallow and deep soil samples from both the Slag Pile and Plant Areas (Figures 4.1.2-1, 4.1.2-2, 4.1.2-5, and 4.1.2-6). The metals most frequently detected at concentrations above screening limits in all soil samples from OU1 were arsenic, cadmium, lead, manganese, and zinc. Cadmium and zinc, however, did not exceed IRSs in soil samples

Measured concentrations of SVOCs were above SVs in only shallow soil samples from the Plant Area (Figure 4.1.2-3), and both shallow and deep soil samples from the Slag Pile Area (Figures 4.1.2-7 and 4.1.2-8). The SVOC most frequently detected at concentrations above screening limits in all soil samples from OU1 was benzo(a)pyrene.

Measured concentrations of two PCBs (Aroclors 1254 and 1260) were above SVs in one shallow soil sample from the Plant Area (Figure 4.1.2-4). No PCBs were detected in deep soil samples from the Plant Area or in Slag Pile Area soil samples.

Measured concentrations of VOCs and pesticides were below SVs if detected in OU1 soil samples.

4.3.1.2 OU1 Groundwater Results

As discussed in [Section 4.1.3](#), measured concentrations of several metals, one SVOC, and two VOCs were above SVs in groundwater samples from the Slag Pile and Plant Areas (Tables 4.1.3-2 and 4.1.3-7).

Metals are widespread in groundwater samples collected from OU1. Several metals were present at concentrations above SVs in groundwater samples from both the Slag Pile and Plant Areas (Figures 4.1.3-1, 4.1.3-2, 4.1.3-5 and 4.1.3-6). The metals most frequently detected at concentrations above SVs in all groundwater samples from OU1 were arsenic, cadmium, chromium (total), manganese and zinc. Lead and cobalt were also more commonly found in groundwater samples from the Plant Area, but less frequently in the Slag Pile.

Measured concentrations of two VOCs (1,2-dichloroethane and VC) were above SVs in one groundwater sample from the Plant Area (Figure 4.1.3-3). VOCs were below SVs in groundwater samples from the Slag Pile Area.

Measured concentrations of bis(2-ethylhexyl)phthalate were above SVs in one groundwater sample from the Plant Area (G-106 collected on 11/1/1991 in Figure 4.1.4-4). SVOCs were below SVs in groundwater samples from the Slag Pile Area.

Measured concentrations of pesticides and PCBs were below SVs, if detected, in all OU1 groundwater samples.

4.3.1.3 OU1 Surface Water and Sediment Results

As discussed in [Section 4.1.4](#), measured concentrations of several metals, SVOCs, one VOC, seven pesticides, and three PCBs were above SVs in sediment samples from OU1 (Tables 4.1.4-3 and 4.1.4-9).

Measured concentrations of several metals were above SVs in surface water samples from the LVR (Table 4.1.4-10). The metals most frequently detected at concentrations above SVs in surface water samples from OU1 included the following:

- Aluminum
- Cadmium
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Zinc

The metals most frequently detected above SVs in sediment samples included the following:

- Arsenic
- Cadmium
- Chromium (total)
- Copper
- Lead
- Mercury
- Nickel
- Silver
- Zinc

Measured concentrations of several SVOCs were above SVs in sediment samples from the Slag Pile Area and LVR (Figures 4.1.4-2 and 4.1.4-7). No SVOCs were detected above method detection limits in the surface water samples from OU1.

Measured concentrations of three PCBs (Aroclors 1242, 1254, and 1260) were above SVs in five sediment samples from LVR and two sediment samples from the Slag Pile Area (Figures 4.1.4-10 and 4.1.4-4). With the exception of one detection from sediment at the seep location, the detections and exceedances for samples in the LVR and the Slag Pile sediments were from the early 1990s. More recent sampling in nearby locations did not detect any PCBs above the method detection limits in sediment samples from the LVR. No PCBs were detected above method detection limits in OU1 surface water samples.

Detectable concentrations of ten pesticides were measured in LVR sediment samples. Concentrations exceeded SVs for seven of these pesticides (Table 4.1.4-17). These detections and exceedances were measured in samples from the early 1990s. More recent sampling did not detect any pesticides above the method detection limits in sediment samples from the LVR. No pesticides were detected in surface water samples from OU1.

4.3.2 **OU2**

This section discusses the OU2 soil/solid, groundwater, surface water, and air sample results. For the purposes of this discussion, the soil, building material, and pile results in [Section 4.3.2.1](#) are summarized together under soil/solid results. Table 4.3.2-1 summarizes contaminants detected at concentrations exceeding the SVs in more than one sample per medium (soil, building material, pile, groundwater, surface water, and air).

4.3.2.1 **OU2 Soil/Solid Results**

For OU2, the term “soil/solid” includes solid matrix materials comprising the unconsolidated surface deposits. These materials consist of natural soils and glacial deposits, some of which have been reworked; slag, sinter, and other by-products of zinc smelting operations; and some fraction of brick, ceramic, and other building debris disposed of along with the sinter and slag materials. The aboveground building material and debris pile results also are discussed below as “soil/solid” results.

Soil samples in OU2 were collected during both Phase I and Phase II field investigations as discussed in [Section 4.2.2](#). SulTRAC advanced a total of 257 borings within the boundaries of OU2 during Phase I and Phase II investigation activities. An additional 10 soil borings were advanced off-site within a 3-mile radius of the Matthiessen and Hegeler Zinc Company Site for background soil sampling. All surface soil samples were collected from 0 to 2 ft bgs. Subsurface soil samples from selected locations were collected for laboratory analysis from the 2-ft interval with the highest apparent contamination based on both field

observations and PID screening results. When field screening results and observations did not identify an interval for sampling and analysis from 2 to 12 ft bgs, samples were collected from the shallowest of the following: above the water table, above bedrock, or the 8- to 10-ft-bgs interval. The soil samples were analyzed for a combination of the following: total metals, total metals by XRF, cyanide, VOCs, SVOCs, PCBs, pesticides, asbestos, TCLP metals, and SPLP metals. Table 4.3.2-1 summarizes the results. The primary contaminants of interest in the surface and subsurface soil samples are metals, PAHs, PCBs, and asbestos. In general, analytical results indicate that: 1) surface soil contains higher contaminant concentrations than subsurface soil; 2) contaminants are distributed throughout OU2; and 3) surface soil sample results indicate a greater extent of impact than subsurface soil sample results.

Building material samples were collected from OU2 as discussed in [Section 4.2.3](#) in order to assess future disposal options, including on-site placement as fill material. Building materials are composed of concrete, brick, stone, wood, and other materials (such as mortar and ceramic piping). Table 4.3.2-1 summarizes the results. The primary contaminants of interest in the building material samples are metals, PAHs, PCBs, and asbestos. PAHs primarily were limited to building material samples composed of wood. Two of the five samples testing positive for asbestos were collected from building materials likely manufactured using asbestos.

Debris pile samples were collected from OU2 as discussed in [Section 4.2.4](#) in order to assess future disposal options, including on-site placement as fill material. Pile samples were collected as surface grab samples from aboveground debris piles during the Phase I field investigation. Table 4.3.2-1 summarizes the results. The primary contaminants of interest in the pile samples are metals, PAHs, PCBs, pesticides, and asbestos.

4.3.2.2 OU2 Groundwater Results

Groundwater MWs were installed and samples were collected across OU2 as discussed in [Section 4.2.5](#) to address potential off-site migration, potential risk to receptors, and the need for future remediation.

Groundwater MWs in OU2 were installed in two water-bearing zones, WBZ1 and WBZ2. WBZ1 wells are screened in the unconsolidated aquifer, and WBZ2 wells are screened in the bedrock aquifer below the unconsolidated deposits. The groundwater MWs were sampled up to eight times between November 2007 and October 2009. Nineteen groundwater MWs were installed in Summer 2007, and 17 additional wells were installed in Summer 2008. Each OU2 MW has been sampled two to eight times, depending on installation date and groundwater levels (some wells were periodically dry or exhibited very slow recharge).

Table 4.3.2-1 summarizes the results. Samples from WBZ1 wells in OU2 exhibited higher contaminant concentrations, primarily metals, than samples from WBZ2 wells. WBZ1 wells primarily are screened at shallower depths than WBZ2 wells and therefore closer to impacted surface soil and surface discharges. The highest metals concentrations were detected in groundwater samples from WBZ1 wells in the former main industrial area of OU2. Some VOCs were detected in OU2 groundwater wells near the Rolling Mill building along the southern boundary of OU2. PAHs were detected near the former ASTs in MW10 northeast of Building 100. Also, both VOCs and SVOCs were detected at localized wells.

4.3.2.3 OU2 Surface Water Results

The surface water samples collected from OU1 and OU2 differ in nature in that OU1 surface water samples were collected from the LVR and OU2 surface water samples were collected from intermittent or ephemeral streams and pools and areas of standing water within manmade vessels.

The OU2 surface water samples were collected over two sampling phases, Phase I and Phase II, which both included two rounds of sampling as discussed in [Section 4.2.6](#). Phase I surface water samples were collected from three locations where flowing ephemeral and intermittent streams occurred, one location in a standing body of water in a vessel containing an AST and one each from the source, middle, and mouth of the stream that flows from the abandoned sewer line into the LVR. The Phase II surface water sampling locations included the source and mouth of the same stream, one location in the north area where standing water often was observed, and two locations of discharge from the former main industrial area.

Table 4.3.2-1 summarizes the results. The primary contaminants of concern in the OU2 surface water samples are metals, especially arsenic, cadmium, lead, mercury, and zinc. Most samples containing contaminant at levels exceeding the SWSVs were collected from the central portion of the former main industrial area of OU2 within manmade structures. The highest metals concentrations were detected in samples collected from the former acid tank (SW018) and in the area near the drainage wall (Figure 5.5.4-1).

4.3.2.4 OU2 Air Results

Two asbestos air sampling events were conducted to assess exposure and risks associated with asbestos inhalation at OU2. The passive sampling event was conducted on July 9, 2008, and the ABS event was conducted on September 30, 2009. None of the sample results from either sampling event tested positive

for asbestos above the detection limit, which ranged from 0.005 to 0.006 f/cc. Because no air sample results exceeded the detection limit, Table 4.3.2-1 does not present the air sample results.

4.3.3 **Border Areas**

The border areas are described in the following sections in an effort to characterize those areas where the investigations of OU1 and OU2 merge. The border areas are characterized for the soil data utilizing those sample locations within a 100 ft radius of the boundary between OU1 and OU2. For the groundwater characterization, the groundwater contours suggest there is little groundwater migration across the border between OU2 and the OU1 Plant Area. Groundwater gradients indicate flow is typically toward the LVR with discharge along the banks of the LVR. The border area for the purpose of characterizing groundwater utilizes data from those wells closest to the LVR in both OU1 and OU2.

4.3.3.1 **Border Areas Soil Summary**

To complete the soil results summary for the Matthiessen and Hegeler Zinc Company Site as a whole, an OU-unified interpretation of the OU1 and OU2 soil results from the areas that border each other is presented in this section. For the purposes of this synthesis, all soil sampling locations from along the southern OU1/OU2 border (along 9th Street) and along the eastern OU1 (Slag Pile)/OU2 border are shown in Figure 4.3.3-1. These areas are referred to as the “border areas”. The border areas sampling locations have been plotted in the context of 0 to 100 ft and 100 to 200 ft contour intervals, with respect to the OU2 southern border and the Slag Pile border.

Initially, a data review was conducted for all soil boring results within 0 to 100 ft of the border on both the OU1 side and the OU2 side. On the OU1-side of the southern border there are five soil boring locations with samples collected for various analytes and at various depths. Table 4.3.3-1 shows the specific depths and analytes sampled. On the OU2-side of the southern border there are three soil boring locations with samples collected for metals, VOCs, SVOCs, PCBs, and pesticides at both surface (0-2 ft) and subsurface (2 to 12 ft) intervals. Asbestos was also sampled at all OU2 surface soil boring locations. Additionally, there are nine locations where surface soils (0 to 1 ft bgs) were screened using an XRF for arsenic, cadmium, lead, and zinc. Some of the XRF screened soil samples were also sent to an analytical laboratory for confirmation and calibration purposes. The XRF was used as this area along 9th Street could not be cleared for soil intrusive work due to the overhead and below-ground utilities present.

Within the 0 to 100 ft contour interval, on the OU1-side of the Slag Pile border area, there is one soil boring location with samples collected for metals at the surface (0 to 1 ft bgs) interval, metals, SVOCs,

and VOCs at the subsurface (10.5 to 11.5 ft bgs) interval, and metals at an additional subsurface (12 to 13 ft bgs) interval. Four surface soil locations (0 to 1 ft bgs) were screened using an XRF for arsenic, cadmium, lead, and zinc. For the same 0 to 100 ft contour interval, on the OU2-side of the Slag Pile border area, there are eight soil boring locations with samples collected for metals, VOCs, SVOCs, PCBs, and pesticides at both surface (0 to 2 ft bgs) and subsurface (2 to 10 ft bgs) intervals. Asbestos was also sampled at all OU2 surface soil boring locations. Additionally, there are nine locations where surface soils (0 to 1 ft bgs) were screened using an XRF for arsenic, cadmium, lead, and zinc. It is noted that all 12 XRF soil sampling locations, were collected and screened by SulTRAC for OU2 soil nature and extent characterization, of which four were collected on the OU1-side of the border (Figure 4.3.3-1). Some of the XRF screened soil samples were also sent to an analytical laboratory for confirmation and calibration purposes.

The above data are also summarized in Figure 4.3.3-1 and Table 4.3.3-1, showing that the sampling locations are fairly sparse on the OU1-side of the Slag Pile border area. Along the OU2-side of the southern border, there are only two soil borings with the remainder of the data being XRF calibrated measurement of metals in surface soils. For these reasons, soils collected and analyzed from the 100 to 200 ft contour interval from the Site border are also considered and included in the soil border area summary. It is recognized that some of these data may not be directly characteristic of the border itself, as they may indicate more OU-specific conditions. However, with the paucity of data points, and recognizing that OU-specific activities may impact the border areas, the 100 to 200 ft contour interval is included and described below.

Within the 100 to 200 ft contour interval, on the OU1-side of the southern border, there are an additional four soil boring locations with samples collected for metals in three of the locations and SVOCs and VOCs in the fourth location. These samples were collected at either surface or subsurface depths (Table 4.3.3-1). On the OU2-side of the southern border, there are an additional nine soil boring locations with samples collected for metals, VOCs, SVOCs, PCBs, and pesticides at both surface (0 to 2 ft) and subsurface (2 to 12 ft) intervals. Asbestos was also sampled for at all OU2 surface soil boring locations.

Within the 100 to 200 ft interval, on the OU1-side of the Slag Pile border, there are an additional four soil boring locations with samples all collected for metals and a variety of other analytes as shown in Table 4.3.3.-1 at various surface and subsurface depths. On the OU2-side of the Slag Pile border, in the 100 to 200 ft contour interval, there are an additional four soil boring locations with samples collected for metals, VOCs, SVOCs, PCBs, and pesticides at both surface (0 to 2 ft) and subsurface (2 to 12 ft) intervals. Asbestos was also sampled for at all surface soil boring locations except SB460 and an

additional sample was collected at depth at SB107. There are three additional locations where surface soils (0 to 1 ft) were screened using an XRF as described above.

Within the border areas, metals are the most wide-spread COIs. This finding is likely somewhat biased by the fact that the XRF measurements are indicative of the metals contaminants, and do not evaluate any of the organic contaminants. However, the frequent detections of metals in these border samples is the case for both surface and subsurface samples, and the XRF measurements are limited to the surface soils. This characteristic of wide-spread metals exceedances appears to be representative of the border areas as well as the rest of the Site.

Arsenic is the most frequent COI in exceedance of the SVs within the metals detected in the border areas. Arsenic is frequently the only contaminant that exceeds the SV in an individual sample. Measured arsenic levels exceed the RRSL, the IRSL and frequently the BTV. Cadmium, lead, manganese and zinc are the other COIs that are frequently in excess of the SVs. Of these, manganese is the only contaminant in addition to arsenic where the BTV is above the RSLs and the measured concentration exceeds the BTV in addition to the RRSL and IRSL. Other contaminants that are detected in excess of the SVs in the border areas are antimony, cobalt, and iron.

SVOCs were also relatively wide-spread in the soil samples with exceedances of SVs in the border areas. SVOCs were somewhat more frequently detected in samples in OU2 than in samples from OU1 border areas. Within the 100 ft radius of the border, one sample from OU1 and 10 samples from OU2 exceed the SVs for SVOCs. The sample exhibiting exceedances in OU1 was in the Plant Area. No SVOC exceedances were noted in the Slag Pile border area of OU1. For the OU2 border areas, SVOC exceedances were noted in both the southern border with the OU1 Plant Area and along the border with the Slag Pile.

Benzo(a)pyrene was the most common SVOC detected. Frequently benzo(a)pyrene was the only SVOC detected above the SV. Other SVOCs detected in both OU1 and OU2 consisted of benzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, benzo(g,h,i)perylene and benzo(k)fluoranthene. The SVOC exceedances of SVs measured in the borings in the border areas were for both RRSLs and IRSLS.

PCBs were detected in samples from the border areas, but were detected only in samples from OU2. Three samples from OU2 exhibited PCB levels in excess of the SVs, and these samples were from the broader 200 ft radius samples. Those three samples were from along the southern border area with the OU1 Plant Area. No PCBs were detected in samples along the Slag Pile border area.

No VOCs above SVs were evident in samples from the border areas of either OU1 or OU2. Similarly, no pesticides were measured above SVs in samples from the border areas of OU1 or OU2.

Asbestos was analyzed for in soil samples from OU2. No asbestos analyses were conducted on soil samples from OU1. No asbestos was detected at the reporting limit of 0.25 percent asbestos in any of the samples from the border area.

4.3.3.2 Border Areas Groundwater Summary

To present a comprehensive site-wide summary of the groundwater results, the data from MWs located adjacent to the LVR or the Slag Pile have been examined further. Specifically, OU1 and OU2 MWs adjacent to the Slag Pile and LVR represent OU1/OU2 border areas and are referred to in this way. MWs in consideration are shown in Figure 4.3.3-2.

MWs in OU1 include well nests at MW301H and MW301S, MW303H and MW303S, and MW305H, MW305S and MW305R. Individual monitor wells are represented at MW2, MW320H, MW321H, and MW322H. Additionally, five piezometers were installed in the Slag Pile, P1, P15 and P15A as a nest of piezometers, P17, and P18. Two interstitial sampling points were also installed by hand at the toe of the Slag Pile along the bank of the LVR at ISW001 and ISW002.

On OU2, there are four MWs in consideration for this groundwater border area synthesis. MW08 and MW18 are OU2 MWs that borders the Slag Pile. MW08 is approximately 30 ft from the border with OU1 and the Slag Pile, and approximately 520 ft from the LVR. MW18 is approximately 50 ft north of the Slag Pile. MW18, MW19, and MW22 are all OU2 MWs located proximal to the LVR at distances of approximately 75 ft, 380 ft, and 175 ft, respectively. These three MWs are located north of the Slag Pile and have associated groundwater flow towards the LVR. Specifically, MW18 and MW19 have east to southeast groundwater gradients and MW22 exhibits a gradient to the northeast (Figures 3.3.3-2 and 3.3.3-4). MW08 is screened in WBZ1. The remaining three OU2 MWs are screened in WBZ2, shale and limestone bedrock. These four MWs were sampled quarterly during the OU2 RI field activities for metals (total and dissolved), VOCs, SVOCs, PCBs, and Pesticides (Table 4.2.5-1). MW08, MW18, MW19, and MW22 were sampled at 6, 8, 5, and 5 quarterly events, respectively.

The contaminant distribution in groundwater is of consequence to both those areas where the contamination was evident in analyses of individual wells, and to the areas where the groundwater migrates and discharges to the surface waters. Analyses of those wells along the border areas in particular the area with groundwater gradients trending toward discharge at the LVR are presented on Table 4.3.3-3.

The site-wide groundwater gradients generally trend toward the LVR (Figures 3.2.3-2 through 3.2.3-5). The contaminants in those wells closest to the LVR may represent the chemistry of water discharging from the upland areas of OU1 and OU2 into the LVR.

There are 22 wells that are along the eastern portions of OU1 and OU2, in areas with gradients trending toward discharge at the LVR. Eighteen of these wells are on OU1 and four are on OU2. Within those wells, five COIs were most frequently found to exceed the SVs: manganese (12 wells), arsenic (11 wells), zinc (6 wells), cobalt (6 wells), and cadmium (5 wells). Six other COIs were less frequently found to exceed the SVs, but were found in at least one well to exceed one or more SVs: lead (3 wells), iron (2 wells), nickel, copper, cobalt, and mercury (1 well each).

Contamination was evident in both dissolved and total analyses for most of these COIs. Table 4.3.3-4 shows which contaminants are present in which wells, in either dissolved or total analyses. The abundance of COIs present above the SVs in individual wells varies considerably. Two of the wells closest to the LVR, MW2 and ISW002, had the most frequent exceedances, 8 and 6, respectively. Other wells with frequent exceedances were MW19 (5), MW18, MW322H, and ISW001 (4), and numerous wells with 3 or less COI exceedances.

In addition to investigating those wells that exhibit contamination in excess of the SVs, note that several wells in this area draining toward the LVR do not show any exceedances. The following wells in the Slag Pile Area of OU1 did not show any exceedances of the total or dissolved metals: P15A, MW301H, MW301S, MW303S, MW305S, MW305R, and MW320H. These wells were installed and used to measure water levels. These wells provide stabilized water levels when allowed to recharge over a sufficiently long time; however, they have been found to recharge sufficiently slowly after pre-sampling development that they have insufficient water to sample. They are part of the OU1 groundwater monitoring network of wells, but do not have analytical data indicating the presence of exceedances.

5.0 CONTAMINANT FATE AND TRANSPORT

The following sections discuss the physiochemical factors affecting chemical fate and transport ([Section 5.1](#)), chemical persistence ([Section 5.2](#)), expected chemical fate and transport ([Section 5.3](#)), potential contaminant migration routes for OU1 ([Section 5.4](#)), and potential contaminant migration routes for OU2 ([Section 5.5](#)). It should be noted that the discussions of COIs in [Sections 4](#) and [5](#) of this RI Report refer to those COIs that exceed one or more of the screening levels referenced. In [Sections 7](#) and [8](#), the Human Health and Ecological Risk Assessments, the discussions refer to contaminants of potential concern (COPCs), selected based on US EPA-mandated risk assessment procedures that are the basis for the Risk Assessment.

5.1 PHYSIOCHEMICAL FACTORS AFFECTING CHEMICAL FATE AND TRANSPORT

There are several physical and chemical (or physiochemical) factors that affect the likely fate and transport of chemical compounds in the environment. The following sections include background information on the primary physiochemical factors that have the potential to influence the fate and transport of COI investigated at OU1 and OU2.

The fate of chemicals in the environment is complex and dictated by a variety of processes that may be occurring at varying degrees, at times reversibly, and often times concomitantly, including the following processes:

- Dissolution in the water column
- Volatilization into the atmosphere
- Adsorption to sediment, which may be subsequently deposited or suspended in the water column
- Leaching from soils into groundwater

There are several factors that may influence the transport and fate of COIs at OU1 and OU2. The primary applicable factors evaluated include the following:

- Water solubility
- Partitioning to sediment
- Vapor pressure
- Gas partitioning
- Soil chemistry (e.g., soil pH, presence of anions, etc.)
- Physical transport factors

These factors are described in greater detail in the following sections.

The primary COIs at OU1 and OU2 include both organic and inorganic compounds. Listed in Table 5.1-1 are available transport factors for organic COIs at OU1 and OU2. The list of COIs includes chemicals that were measured at concentrations above SVs (February 2010). Relevant transport factors for Site constituents are summarized in Table 5.1-1 and discussed below.

5.1.1 Water Solubility

The water solubility (also “solubility”) of a chemical is a measurement of the extent to which a chemical can dissolve in water. Solubility is typically expressed as the mass of a chemical that can dissolve in a certain quantity of water (e.g., mg/L). A chemical that has high solubility will completely dissolve in water (also “fully miscible”). A chemical that has low solubility will remain in its original state (e.g., solid, liquid, or gas), will only partially dissolve in water, and will not become a homogeneous solution in water (also “immiscible”).

The solubility of a chemical is important because it partly influences the extent to which a substance can partition between soil and groundwater or between sediments and surface water or groundwater. Because water is a polar solvent, polar covalent and ionic compounds are more likely to dissolve than non-polar compounds. Dissolution of non-polar organic chemicals is further controlled by their affinity for organic carbon phases in sediments or water.

The available solubility data for each COI are listed in Table 5.1-1.

5.1.2 Adsorption/Partitioning

Adsorption (also partitioning) is the ability of a substance to bind to the surface of soil particles as a result of reactions that occur between the chemical and soil particle surface. The aqueous concentration of chemicals in soil systems can be substantially influenced by adsorption reactions to the soil matrix. The tendency for a chemical to be adsorbed is a function of the nature of the chemical and the site-specific soil properties, and is typically quantified by a distribution coefficient (K_d). K_d is a measure of the ratio of chemical mass that partitions to the solid and liquid phases under equilibrium conditions (Table 5.1-1). Constituents with higher K_d values are more likely to sorb to soils and sediments, while constituents with lower K_d values are less likely to sorb and may be mobilized to groundwater or surface waters.

The following subsections provide an overview of inorganic partitioning ([Section 5.1.2.1](#)) and organic partitioning ([Section 5.1.2.2](#)).

5.1.2.1 Inorganic Partitioning

Inorganic compounds are commonly bound to the soil or sediment through a number of processes that are commonly referred to as inorganic partitioning (also “soil binding”). Inorganic partitioning, by this definition includes: 1) the electrostatic binding of an inorganic to the soil or sediment; and 2) precipitation of the inorganic compound with other ions to form an insoluble mineral. In addition to these processes, an inorganic compound may undergo both reactions where an inorganic compound is immobilized through electrostatic binding with subsequent precipitation around the sorbed species resulting in further reduction in the potential for an inorganic to be remobilized. Table 5.1.2-1 provides a summary of the potential aqueous or soluble forms in the environment, and the major immobilization/partitioning processes for Site inorganics that includes geochemical conditions that, if present, may increase mobility.

Inorganic compounds are commonly bound to soil particles as a result of electrostatic interactions. For example, the mineral hydrous ferric oxide (FeOOH) is a dominant sorbent for many inorganic compounds (e.g., arsenic, cadmium) at a range of pH values owing to its common presence on soil particle surfaces, high surface area, and amphoteric character. Oftentimes, site-specific K_d values for inorganic compounds are correlated to the concentration of hydrous ferric oxide in the soil matrix.

Precipitation is a major immobilization/partitioning processes for most inorganics. Under reducing conditions, the precipitation of immobile metal-sulfide complexes has been noted for antimony, arsenic, cadmium, nickel, zinc, and copper. Similarly, several inorganic cations (e.g., lead, cobalt, and barium) precipitate as relatively immobile metal-carbonate complexes.

Consequently, the overall mobility of inorganic compounds is highly dependent upon the soil and/or groundwater chemistry conditions, as discussed further in [Section 5.1.4](#).

5.1.2.2 Organic Partitioning

Organic compounds are frequently non-polar and thus tend to interact with organic matter commonly associated with the soil matrix. The general tendency of an organic chemical to be adsorbed by soils may be assessed by the adsorption coefficient for organic carbon (K_{OC}).

The K_{OC} value is the ratio of the mass of an organic chemical that is adsorbed in the soil per unit mass of organic carbon in the soil at equilibrium. It is a measure of the tendency of the compound to adsorb onto carbon in the soil, such that the lower the K_{OC} value, the more mobile the contaminant in soil systems.

The octanol-water partition coefficient (K_{OW}) is the distribution of an organic compound between water (a polar solvent) and *n*-octanol (a non-polar solvent). The higher the K_{OW} value, the more hydrophobic the compound, and therefore, the less likely the compound is to remain in solution in water. Both K_{OC} and K_{OW} may be used to predict the degree of sorption to organics in soil, sediment and particulate matter, and therefore, chemical mobility.

The site-specific K_d values for organics listed in Table 5.1-1 were estimated by assuming that 0.2 percent of soil is organic carbon (fraction of organic carbon or f_{OC}) (IDEM 2007):

$$K_d = 0.63 * f_{OC} * K_{OW}$$

The octanol-water coefficient (K_{OW}) is described in [Section 5.1.2.2](#).

5.1.3 Vapor Pressure and Henry's Law Constant

Vapor pressure and the Henry's law constant (K_H) are indications of how readily a compound will volatilize from solution in water into the atmosphere. These properties are grouped because of their interrelationship through Henry's law. Vapor pressure and K_H influence whether a pollutant is more likely to be present in the liquid or gaseous phase. Compounds with low K_H values tend to remain in solution versus volatilizing into the air. The available vapor pressure and Henry's law constants for the COIs are listed in Table 5.1-1.

5.1.4 Soil Chemistry

Soil chemistry conditions, such as soil or groundwater pH, presence of other cations and anions, and saturated or unsaturated conditions, are important factors that dictate the fate and transport of COIs. The soil pH may influence the dominant ionic form of a metal contaminant and therefore, whether the metal will be present in a soluble or insoluble form. The pH also dictates the stability of and number of cation and anion sorption sites on clay and other soil minerals. For inorganics present as cations (e.g., barium, cadmium, lead, trivalent chromium), sorption is greatest at near neutral to alkaline pHs. At neutral to alkaline pH ranges soil minerals (clays and metal oxides and hydroxides) have more negative charge sites to bind the positively charged cations. Conversely, at more acidic pH ranges these soil minerals have

more positive charge sites that can sorb inorganics that are commonly present as anions (e.g., hexavalent chromium, arsenate).

The presence or absence of other cations and anions may impact the speciation of the contaminant and/or may compete with a contaminant (e.g., phosphate competition with arsenic) for sorption sites and thus increase contaminant mobility. Conversely, many of these same cations and anions may precipitate out with metals reducing their solubility/mobility.

Saturated or unsaturated soil conditions create anoxic or oxic environments, which may catalyze geochemical transformations and affect the dominant contaminant species present for mobilization or immobilization. In addition to affecting the potential metal speciation, redox may play an important role in sorption/desorption reactions, and precipitation/dissolution reactions. If soil becomes anoxic/reducing, iron minerals that may be currently sorbing inorganic COIs may be reduced, which could release the previously sorbed cation or anion. Reducing conditions are also required to immobilize several metals (e.g., iron, arsenic, and lead) through the precipitation of stable metal sulfide minerals. If a previously reduced solid (soil or sediment) becomes oxidized (for example, dredging of sediments and placing them at the surface where they are exposed to oxygen), previously present metal sulfide minerals may undergo oxidative dissolution where the metal is released, sulfide is oxidized to sulfate, and the soil or groundwater becomes more acidic.

5.1.5 Physical Transport Factors

COIs can be physically transported while present in surface water or groundwater (either in solution, or adsorbed to particles), or air (either as volatilized compound, or adsorbed to particles). Potential physical transport factors are erosion and/or solution of erosion, surface water flow, groundwater flow, as well as fugitive dust generation by wind or air flow.

As described in [Section 1.2.1](#), the LVR flows along the eastern border of OU1 and based on vicinity groundwater gradients, appears to be a gaining stream (i.e., groundwater flows from the aquifer to the river). Surface water is the primary transport mechanism for movement of contaminated sediment from OU1 to sites downstream in the LVR. Physical transport of contaminants via surface water flow is mainly dependent upon the river flow velocity and sediment particle characteristics. Chemicals adsorbed to sediments and organic matter may be transported in suspension or as bed load by river currents. Fine-grained material, such as silts and clays, will generally be entrained in the water column and migrate downstream as suspended solids. As water velocities increase due to storm events or seasonal runoff,

coarser-grained material (medium- to coarse-grained sand or larger particles) will become suspended and/or move along the river bottom as bed load. Chemicals may accumulate in sediment deposits as river velocities decrease. After initial deposition, bottom sediments are subject to resuspension.

Substances dissolved in surface water can partition out of the dissolved phase to a solid phase or adsorb onto particles suspended in the water or onto bottom sediment. The latter process transfers the substances from the water to the sediment matrix. Conversely, chemicals may desorb from sediment back into the water.

5.2 CHEMICAL PERSISTENCE

Chemical persistence is the resistance of a chemical to degradation or other transformation in the environment. Factors affecting chemical persistence are discussed below.

5.2.1 Volatilization

Volatilization is the process by which a chemical changes from a liquid state to a gaseous state and can significantly affect the distribution of a chemical in the environment. In soils, volatilization results in a decrease in the amount of a chemical in soil as the chemical volatilizes to soil gas and ultimately discharges to the atmosphere. The end result is a reduction in chemical concentration in soil over time. Volatilization reactions are most significant in surface soils that are in direct contact or in close proximity to the atmosphere. Chemical volatility is typically quantified by a chemical's Henry's law constant (Table 5.1-1). The majority of the COIs at OU1 and OU2 have low Henry's law constants (less than 0.01) except Aroclor 1248, bromodichloromethane, TCE, PCE, and VC (Table 5.1-1), thus volatilization is not anticipated to substantially influence the fate of most compounds. However, volatilization is a key removal pathway for VOCs.

5.2.2 Degradation

Numerous chemicals in the environment are subject to naturally occurring biotic and abiotic transformation reactions that result in the degradation of the chemical. Many organic compounds are subject to biodegradation reactions under aerobic and anaerobic conditions. During biodegradation, naturally occurring microorganisms in the subsurface transform a chemical to another state as a direct or indirect consequence of their metabolic processes. Biodegradation reactions can break down organic chemicals to less toxic forms, though this is not always the case. For example, the compound TCE degrades to VC, which is a more toxic form.

Several naturally occurring abiotic reactions can significantly affect the fate of chemicals in the environment. Common abiotic reactions include photodegradation and hydrolysis. Photodegradation is the process of decomposition of a chemical upon exposure to radiant energy such as sunlight, and is most significant to chemicals in surface soil that are in direct contact with sunlight. Hydrolysis is the degradation reaction of the chemical with components of water (e.g., hydroxyl and hydronium ions) and is thus most important in saturated environments.

Degradative processes are unlikely to substantially influence the concentrations of the majority of COIs investigated at OU1 and OU2. None of the metals will be significantly influenced by degradation processes. Most organic compounds are highly stable under most environmental conditions, and the predominant degradation mechanism affecting their fate is photodegradation. However, this process is limited to the uppermost surface soils and is unlikely to substantially influence the overall occurrence of these compounds. Similarly, pesticides, PCBs, and SVOCs investigated as COIs have some potential to degrade in response to abiotic and/or biotic processes; but, the effects of degradation on the fate of these compounds are unlikely to be significant in the near-term.

5.3 EXPECTED CHEMICAL FATE AND TRANSPORT

The expected fate and transport are discussed below for each class of chemicals present at the Matthiessen and Hegeler Zinc Company Site. Summarized in Table 5.1.2-1 are the potential chemical forms, immobilization mechanisms, and mobilization mechanisms of inorganic COIs at OU1 and OU2. Also included in Table 5.1-1 are important chemical properties of organic contaminants of concern that effect their fate and transport. This section provides a description of the general behavior of the inorganic constituents (metals and cyanide) and organic constituents (VOCs, SVOCs, PCBs, pesticides and asbestos) investigated at OU1 and OU2 (Table 4.3.1-1 and 4.3.2-1).

5.3.1 Inorganic Constituents

The inorganic COIs present at OU1 and OU2 are primarily heavy metals. The key factors that influence the fate and transport of heavy metals are their speciation and adsorption capacity. Adsorption capacity is dependent upon the presence of competing ions (e.g., phosphate, sulfate, bicarbonate), water chemistry, and metal speciation, which is, in turn affected by such factors as pH and ORP. The relative proportion of metals between the dissolved and particulate phases is controlled by a complex combination of precipitation and sorption reactions. The inorganic COIs that were present at concentrations above SVs were the following:

- | | | |
|-------------|-------------|------------|
| • Aluminum | • Chromium | • Mercury |
| • Antimony | • Cobalt | • Nickel |
| • Arsenic | • Copper | • Selenium |
| • Asbestos | • Cyanide | • Silver |
| • Barium | • Iron | • Thallium |
| • Beryllium | • Lead | • Vanadium |
| • Cadmium | • Manganese | • Zinc |

The predicted fate and transport of each inorganic COI are described in the following subsections. The predicted fate and transport of asbestos is described in [Section 5.3.6](#).

5.3.1.1 Aluminum

Aluminum was detected at concentrations above SVs in total aluminum analyses of groundwater samples from the Plant Area, and totals analysis of surface water samples from the LVR at OU1 (Table 4.3.1-1).

The behavior of aluminum in the environment is strongly influenced by its coordination chemistry. Aluminum partitions between solid and liquid phases by reacting and complexing with water molecules and anions such as chloride, fluoride, sulfate, nitrate, phosphate, and negatively charged functional groups on humic materials and clay. In general, decreasing pH (acidification) results in an increase in mobility for monomeric forms of aluminum (Goenaga and Williams 1988), which is of concern with respect to the occurrence of acid rain and the release of acid mine drainage. Aluminum in soil matrices and surface waters in a mining region rich in metallic sulfides was in a labile form, as Al-SO_4 and Al^{3+} species. Acidic conditions were created by the microbial oxidation of sulfides in tailing piles, resulting in sulfuric acid. In contrast, in areas not affected by acidification, aluminum in solution was partitioned between labile and non-labile forms, the latter being predominantly bound to fluorine (Alvarez *et al.* 1993). In more alkaline solutions, hydroxyl complexes of aluminum (Al(OH)_2^+ , Al(OH)_3^0 , and Al(OH)_4^-), many of which are soluble, will be dominant (Rai *et al.* 1984). Should highly alkaline conditions be potentially developed during certain of the remedial measures under consideration, the impact on aluminum mobility will be taken into consideration. In soils, the most soluble form of aluminum under acidic conditions is nonsiliceous, organically-bound aluminum (Mulder *et al.* 1989). In groundwater or surface water systems, equilibrium with a solid phase form is established that largely controls the extent of aluminum dissolution which can occur.

5.3.1.2 Antimony

Antimony was detected at concentrations above SVs in deep soil samples from the Slag Pile Area (Table 4.3.1-1). Antimony was also detected at concentrations above SVs in building material, pile, and SPLP soil samples at OU2 (Table 4.3.2-1).

Antimony is expected to be less mobile under circumneutral to acidic pH conditions, but redox conditions may also play a major role in mobility. Antimony is commonly associated with nonferrous ore deposits and is emitted to the environment during the smelting of these ores. Antimony is predominantly associated with small, submicron particles (Stoessel and Michaelis 1986), and exhibits similar geochemical behavior to that of arsenic. Therefore, it is generally mobile under reducing conditions as well as higher pH conditions.

Little is known of the adsorptive behavior of antimony, its compounds, and ions. The binding of antimony to soil is influenced by the nature of the soil and the form of antimony deposited on the soil. Some forms of antimony may bind to inorganic and organic ligands. On the other hand, a mineral form would be unavailable for binding. Some studies suggest that antimony is fairly mobile under diverse environmental conditions (Rai and Zachara 1984), while others suggest that it is strongly adsorbed to soil (Ainsworth 1988; Foster 1989; King 1988). Since antimony concentrations were below SVs in groundwater and surface water samples from OU1, its mobility is likely limited. Antimony is known to form coprecipitates with hydrous iron, manganese, and aluminum oxides in soil and sediment (Callahan *et al.* 1978).

5.3.1.3 Arsenic

Arsenic was detected at concentrations above SVs in soil samples from the Plant and Slag Pile Areas, sediment samples from the Slag Pile Area and LVR, and both total and dissolved analyses of groundwater samples from the Plant and Slag Pile Areas at OU1 (Table 4.3.1-1), and building material, pile, soil, groundwater, both total and dissolved phase, and surface water samples at OU2 (Table 4.3.2-1).

Arsenic in soil may be transported as fugitive dust by wind or in runoff or may leach into the subsurface soil. However, because many arsenic compounds tend to partition to soil or sediment under oxidizing conditions, leaching usually does not transport arsenic to any great depth (US EPA 1982; Moore *et al.* 1988; Pansar-Kallio and Manninen 1997; Welch *et al.* 1988). Arsenic is largely immobile in agricultural soils; therefore, it tends to concentrate and remain in upper soil layers indefinitely. Downward migration has been shown to be greater in a sandy soil than in a clay loam (Sanok *et al.* 1995). The most influential

parameter affecting arsenic adsorption in soil is the iron content of the soil (Janssen *et al.* 1997). Note that iron concentrations in soil samples were also above SVs (Table 4.3.1-1 and [Section 4.1.2](#)).

Transport and partitioning of arsenic in water depends upon the chemical form of the arsenic and on interactions with other materials present. Soluble forms move with the water, and may be carried long distances through rivers (US EPA 1979). However, arsenic may be adsorbed from water onto sediments or soils, especially clays, iron oxides, aluminum hydroxides, manganese compounds, and organic material (US EPA 1979, 1982; Welch *et al.* 1988). Under oxidizing and mildly reducing conditions, groundwater arsenic concentrations are usually controlled by adsorption rather than by mineral precipitation. In acidic and neutral waters, As (V) is extensively adsorbed, while As (III) is relatively weakly adsorbed.

Both biotic and abiotic reduction by sulfides may play an important role in arsenic redox chemistry (Rochette *et al.* 2000). Microbial reduction of arsenate occurs through the respiration and detoxification mechanisms of *E. Coli* and *Staphylococcus* bacteria (Jones *et al.* 2000). Under highly reducing conditions, sulfide (as H_2S and HS^-) is capable of reducing As (V) to As (III) without microbial mediation; however, the reduction rate is highly pH dependent. Reaction kinetics of arsenate reduction by sulfides is slow at neutral pH; whereas, a pH of 4 can increase the reduction rate by 300 (Rochette *et al.* 2000). In such environments, dissolved As-S complexes may represent a large fraction of As. Once As (V) is reduced to As (III), it may form several different soluble and insoluble phases with sulfur (Rochette *et al.* 2000). These phases may provide an important sink for arsenic in the environment via the formation of surface precipitates similar to arsenopyrite (Bostick and Fendorf 2003a; Bostick and Fendorf 2003b).

5.3.1.4 Barium

Barium was detected at concentrations above SVs in total analysis of groundwater samples from the Plant Area at OU1 (Table 4.3.1-1). All filtered groundwater samples from the Plant Area had barium concentrations less than 50 $\mu g/L$ (Table 4.1.3-3). Barium was not detected at concentrations above SVs at OU2.

In aquatic media with sufficient sulfate and/or carbonate, the major mobility reducing process for barium is likely the precipitation of insoluble salts (i.e., as $BaSO_4$ or $BaCO_3$). Waterborne barium may also adsorb to suspended particulate matter through the formation of ion pairs with natural anions such as bicarbonate or sulfate in the matter (Bodek *et al.* 1988; US EPA 1984; Giusti *et al.* 1993; Lagas *et al.* 1984; Tanizaki *et al.* 1992). Sedimentation of suspended solids removes a large portion of the barium

content from surface waters (Benes *et al.* 1983). There is evidence to suggest that the precipitation of barium from the surface of fresh and marine waters occurs, in part, as the result of the barite (BaSO_4) crystal formation in microorganisms (González-Muñoz *et al.* 2003). Because only unfiltered samples of groundwater resulted in exceedance of SVs for barium, a majority of barium appears to be associated with particulate matter (Table 4.1.3-3).

Barium concentrations in groundwater supplies have been known to exceed US EPA's MCL of 2.0 mg/L (2,000 $\mu\text{g/L}$) (US EPA 2002c); this may be due to leaching and erosion of barium from sedimentary rocks (Calabrese 1977; Kojola *et al.* 1978). For example, community water supplies from deep rock and drift wells in northeastern Illinois have been found to have barium concentrations ranging from 1,100 to 10,000 $\mu\text{g/L}$ (Calabrese 1977).

5.3.1.5 Beryllium

Beryllium was detected at concentrations above SVs in groundwater samples (total analysis only) from the Plant Area at OU1 (Table 4.3.1-1). Beryllium was not detected at concentrations above SVs at OU2.

The mobility of beryllium is dependent upon the stability and availability of sorption sites (negatively charged sites of clays and other soil minerals like carbonates and iron oxyhydroxides). Consequently, the soil chemistry (e.g., pH and redox), which dictates the stability and number of charge sites and the rate and potential for precipitation reactions, is critical to beryllium fate and transport.

In highly alkaline soils, the mobility of beryllium may increase as a result of the formation of soluble hydroxide complexes, such as $[\text{Be}(\text{OH})_4]^{2-}$ (Callahan *et al.* 1979; Cotton and Wilkinson 1980). In acidic soils (e.g., forest ecosystems), dissolved Be^{2+} has been found to be the prevailing beryllium species in the soil matrix, and it should be relatively mobile in these environments (Krám *et al.* 1998). However, leaching would not be expected to occur in less acidic soils (Hayes and Traina 1998).

In the pH range of 6 to 8, typical of most waters, the speciation of beryllium is controlled by the formation of solid beryllium hydroxide, $\text{Be}(\text{OH})_2$, which has a very low solubility. Other transformations of environmental importance are the formation of insoluble basic carbonates, such as $(\text{BeCO}_3)_2\text{Be}(\text{OH})_2$, formed by reaction of dissolved carbonate with beryllium solutions and the formation of beryllium sulfate (i.e., BeSO_4) formed by reaction of soluble sulfates with beryllium solutions.

5.3.1.6 Cadmium

Cadmium was detected at concentrations above SVs in soil and sediment samples from the Slag Pile Area, groundwater samples (both total and dissolved phase) from the Plant and Slag Pile Areas, and surface water (both total and dissolved phase) and sediment samples from the Slag Pile and LVR at OU1 (Table 4.3.1-1). Cadmium was also detected at concentrations above SVs in building material, pile, soil, groundwater (both total and dissolved phase), and surface water samples at OU2 (Table 4.3.2-1).

Similar to lead, the pH of soils, sediments, or groundwater is one of the most important factors affecting cadmium mobility. Acidic conditions favor cadmium solubility and bioavailability. Higher pH conditions favor increased adsorption of cadmium to oxides and oxyhydroxides of iron, manganese, and aluminum, as well as to clay minerals and organic matter. These conditions are also conducive to the formation of sparingly soluble carbonates, hydroxides, and phosphates. While cadmium is not a redox-sensitive metal, low redox potential generally leads to the formation of insoluble cadmium sulfides. Cadmium forms a variety of complexes and chelates. If organic acids (e.g., humic and fulvic acids) are naturally abundant, cadmium can be mobile due to the formation of soluble metal-organic complexes. However, under non-acidic conditions and the presence of solid organic matter, cadmium is generally immobile in the terrestrial environment.

Cadmium is more mobile in aquatic environments than most other heavy metals (e.g., lead). In unpolluted natural waters, most cadmium transported in the water column will exist in the dissolved state as the hydrated ion $\text{Cd}(\text{H}_2\text{O})_6^{2+}$. Minor amounts of cadmium are transported with the coarse particulates, and only a small fraction is transported with the colloids. However, under reducing conditions, cadmium may form cadmium sulfide, which is poorly soluble and tends to precipitate (US EPA 1983; McComish and Ong 1988).

5.3.1.7 Chromium

Chromium was detected at concentrations above SVs in sediment samples from the Slag Pile Area, groundwater samples (total phase only) from the Plant Area, and one surface water sample (total phase only) from the LVR at OU1 (Table 4.3.1-1). Chromium was detected at concentrations above SVs in building materials and groundwater samples at OU2 (Table 4.3.2-1).

Chromium is a redox-sensitive trace metal. Its solubility, mobility, and toxicity are mainly affected by redox potential. Cr (VI) (also “hexavalent chromium”) tends to be reduced to poorly soluble Cr (III) (also “trivalent chromium”) by organic matter, as well as by other reducing agents such as iron and sulfur, in

soils (Brady *et al.* 1998). While the reduced form Cr (III) is relatively benign, Cr (VI) is fairly mobile and toxic. These two oxidation states are the main forms of chromium in the natural environment. Under very acidic conditions (i.e., around pH 2.5), Cr (III) is fairly mobile, while it precipitates out at pH conditions above 4.5. In comparison, Cr (VI), appears to be more mobile under neutral to alkaline conditions since Cr (VI) adsorption decreases with increasing pH. Cr (VI) is present as an anion (thus the higher mobility), while Cr (III) exists mainly as a cation. Soluble organic matter can serve as a chelating agent for Cr (III), as well as an electron donor for the reduction of Cr (VI). Iron and manganese oxides play an important role in chromium chemistry. Manganese oxides provide both adsorption sites for chromium retardation, as well as serve as electron acceptors to allow the oxidation of Cr (III) to Cr (VI) to proceed.

5.3.1.8 Cobalt

Cobalt was detected at concentrations above SVs in soil samples from the Plant Area and Slag Pile Area, one sediment sample from the LVR, and groundwater samples (both total and dissolved phase) from the Plant and Slag Pile Areas at OU1 (Table 4.3.1-1). Cobalt was also detected at concentrations above SVs in pile, soil, groundwater (both total and dissolved phase), and surface water samples at OU2 (Table 4.3.2-1).

The transport and partitioning of cobalt in water and soil is influenced by pH, redox potential, and the presence of particulate matter. The mobility of cobalt in soils is affected by the pH of the soil. Typically cobalt is more mobile than other metals, such as lead, chromium, zinc, and nickel (Kim 2006). Cobalt adsorbs to soil oxides more than other materials. Desorption of cobalt from soil oxides is low, although humic acids can desorb substantial amounts of cobalt (Kim 2006).

5.3.1.9 Copper

Copper was detected at concentrations above SVs in one soil and one groundwater (total phase only) sample from the Slag Pile Area, in surface water samples (both total and dissolved phase), and in sediment samples from the Slag Pile and LVR at OU1 (Table 4.3.1-1). Copper was also detected at concentrations above SVs in pile and soil samples at OU2 (Table 4.3.2-1).

The mobility of copper is largely dependent on the pH of soils, sediments, and groundwater. Copper solubility and bioavailability is drastically reduced at a pH above 7, while pH conditions below 5 favor copper solubility. Organic matter has a high sorption capacity for copper, which generally limits copper mobility. However, in its dissolved form, organic matter (i.e., organic ligands) can also increase the

leachability and transport of copper. Similar to many other trace metals, the amount of oxides and oxyhydroxides of iron and manganese plays an important role in the retention of copper in soils and/or aquifer matrices. Copper can also form sparingly soluble carbonates and hydroxides, and under reducing conditions, copper sulfides.

5.3.1.10 Cyanide

Cyanide was detected at concentrations above SVs in surface water samples from OU1 (Table 4.3.1-1). Cyanide was detected at concentrations above SVs in soil and groundwater samples at OU2 (Table 4.3.2-1).

Cyanide is a chemical group consisting of one atom of carbon connected to one atom of nitrogen by three molecular bonds, and cyanides are compounds that contain a cyanide group (typically shown as CN). Cyanides can both occur naturally or be man-made and many are powerful and rapid-acting poisons. Certain bacteria, fungi, and algae can produce cyanide, and cyanide is found in a number of foods and plants.

Many of the cyanides in soil and water come from industrial processes. The major sources of cyanides in water are discharges from some metal mining processes, organic chemical industries, iron and steel plants or manufacturers, and publicly owned wastewater treatment facilities. Other cyanide sources include vehicle exhaust, releases from chemical industries, burning of municipal waste, and use of cyanide-containing pesticides. Much smaller amounts of cyanide may enter water through storm water runoff where road salts are used that contains cyanide. Hydrogen cyanide, sodium cyanide, and potassium cyanide are the forms of cyanide most likely to be in the environment as a result of industrial activities. Cyanide salts and hydrogen cyanide are used in electroplating, metallurgy, organic chemicals production, photographic developing, manufacture of plastics, fumigation of ships, and some mining processes.

Volatilization of hydrogen cyanide would be a significant loss mechanism for cyanides from soil surfaces at a pH less than 9.2. Cyanides are fairly mobile in soil. Mobility is lowest in soils with low pH and high concentrations of free iron oxides, positively charged particles, and clays (e.g., chlorite, kaolin, gibbsite), and highest in soils with high pH, high concentrations of free CaCO_3 and negatively charged particles, and low clay content (US EPA 1979). Although cyanide has a low soil sorption capability, it is usually not detected in groundwater, probably because of fixation by trace metals through complexation or transformation by soil microorganisms (US EPA 1978c). In soils where cyanide levels are high enough

to be toxic to microorganisms (i.e., landfills, spills), this compound may leach into groundwater (US EPA 1984).

Volatilization and sorption are the two physical processes that contribute to the loss of cyanide from water. At pH below 9.2, most of the free cyanide in solution should exist as hydrogen cyanide, a volatile cyanide form (US EPA 1978). On the basis of Henry's law constant and the volatility characteristics associated with various ranges of Henry's law constant (Thomas 1982), volatilization is a significant and probably dominant fate process for hydrogen cyanide in surface water (US EPA 1992). The most common alkali metal cyanides (e.g., sodium and potassium cyanide) may also be lost from surface water primarily through volatilization; whereas, the sparingly soluble metal cyanides such as copper (I) cyanide are removed from water predominantly by sedimentation and biodegradation (US EPA 1992). Because volatilization is not an important fate process for cyanide in groundwater, cyanide would be expected to persist for considerably longer periods of time in underground aquifers than in surface water.

5.3.1.11 Iron

Iron was detected at concentrations above SVs in soil samples from the Plant and Slag Pile Areas, groundwater samples (both total and dissolved phase) from the Plant and Slag Pile Areas, and surface water samples (total phase only) from the LVR at OU1 (Table 4.3.1-1). Iron was also detected at concentrations exceeding SVs in pile, groundwater (total phase only), and surface water samples at OU2 (Table 4.3.2-1).

The average abundance of iron (Fe) in the earth's crust is 5 percent by weight. The iron content of soils is typically in the range of 0.5 percent to 5 percent, and is dependent upon the source rocks from which the soil was derived, transport mechanisms, and overall geochemical history of the soil. In addition to being commonly found in the environment, iron is reactive and changes readily to different forms with varying solubility. In groundwater, iron occurs in one of two oxidation states. These states include reduced soluble divalent ferrous iron (Fe^{+2}) and oxidized insoluble trivalent ferric iron (Fe^{+3}). Within the pH range of 4 to 9 standard units, iron is predominantly present as free ferrous iron or ferric iron complexed with hydroxyl ions. Consequently, pH exhibits minor controls on iron solubility within the pH ranges normally encountered in the environment. Redox potential, conversely, more directly dictates iron solubility. The more mobile ferrous iron form is prevalent in slightly positive to negative ORP ranges. For ferrous iron, the major solubility reduction process is precipitation as an insoluble iron sulfide (e.g., pyrite). Ferrous iron is soluble as a cation, whereas ferric iron is not. However, ferric iron can form soluble complexes with many inorganic and organic ligands.

The atmosphere has 21 percent oxygen, causing most of the iron in shallow subsurface soils to be in the oxidized ferric state. Ferric hydroxide ($\text{Fe}(\text{OH})_3$) is the direct result of ferrous iron oxidation and precipitation. The principal forms of mineralized ferric iron found in soils are: amorphous hydrous ferric oxide ($\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$), maghemite ($\gamma\text{-Fe}_2\text{O}_3$), lepidocrocite ($\gamma\text{-FeOOH}$), hematite ($\alpha\text{-Fe}_2\text{O}_3$), and goethite ($\alpha\text{-FeOOH}$).

Iron and manganese are frequently associated with each other in natural environments. Like manganese, iron is more soluble and mobile in its reduced form (i.e., Fe (II)) than in its oxidized form (i.e., Fe (III)). In its oxidized form (ferric iron, Fe (III)), iron readily precipitates as oxides, oxyhydroxides, and carbonates, which are immobile species. In its reduced form (ferrous iron, Fe (II)), iron is soluble and mobile. However, in the presence of sulfide, iron precipitates as iron sulfides (FeS and FeS_2), which are immobile unless re-oxidized. Quite frequently, high iron concentrations in groundwater may indicate high arsenic concentrations as well, since arsenic gets mobilized through anaerobic dissolution of iron oxides and oxyhydroxides.

5.3.1.12 Lead

Lead was detected at concentrations above SVs in soil samples from the Plant and Slag Pile Areas, sediment samples from the Slag Pile Area and LVR, groundwater samples (both total and dissolved phase) from the Plant and Slag Pile Areas, and surface water samples (both total and dissolved phase) from the LVR at OU1 (Table 4.3.1-1). Lead was also detected at concentrations above SVs in building material, pile, soil (including SPLP and TCLP soil samples), groundwater (both total and dissolved phase), and surface water samples at OU2 (Table 4.3.2-1).

The pH and redox of soils, sediments, or groundwater are the most important factors affecting lead mobility. Acidic conditions favor lead solubility and bioavailability. Higher pH conditions favor the adsorption of lead to oxides and oxyhydroxides of iron, manganese, and aluminum, as well as to clay minerals and organic matter. Furthermore, the formation of sparingly soluble lead carbonates and phosphates under these conditions limits lead mobility. Under very alkaline conditions, which dissolve organic matter, and/or the presence of natural organic acids (e.g., humic and fulvic acids), lead solubility will increase due to the formation of mobile metal-organic complexes. A low redox potential may lead to the dissolution of iron hydroxides, which would result in increased lead mobility, but it may also favor the formation of insoluble lead sulfides (e.g., galena). In general, high lead concentrations are generally limited to surface soils, and concentrations decrease sharply with depth. Unless surface soils are highly

contaminated, lead is rarely found in dissolved form in groundwater due to its generally low solubility. When lead is detected in groundwater, it is frequently associated with suspended silt and clay particles.

5.3.1.13 Manganese

Manganese was detected at concentrations above SVs in soil samples from the Plant and Slag Pile Areas, sediment samples from the LVR, and groundwater samples (both total and dissolved phase) from the Plant and Slag Pile Areas at OU1 (Table 4.3.1-1). Manganese was also detected at concentrations above SVs in pile, soil, groundwater (both total and dissolved phase), and surface water samples at OU2 (Table 4.3.2-1).

Manganese is a redox-sensitive trace metal. Its chemical behavior is similar to iron, and the two elements are frequently associated with each other in natural environments. Manganese geochemistry is quite complex; it can exist in several oxidation states, with the oxidation states of II, IV, VI, and VII being the most stable. The subject Site began producing potassium permanganate by electrolytic oxidation of alkaline manganate solutions to produce potassium permanganate and other compounds. Consequently, these products were and are likely composed of permanganate (VII) and manganate (VI). Both forms are highly reactive and oxidize a wide variety of inorganic and organic substances. Potassium permanganate is reduced to manganese dioxide (MnO_2) (IV) which precipitates out of solution. As noted, these are rapid reactions and therefore the higher valence states for manganese are not anticipated to be persistent. Manganese minerals are widely distributed, with the most common ones being the oxides, carbonates, and silicates. Divalent manganese (i.e., Mn(II)) is very stable and mobile under acidic conditions, while MnO_2 is stable under more alkaline conditions. Manganese does not form complexes with ligands as readily as other trace elements. The soil pH is the most important variable affecting manganese mobility. However, the redox potential of a natural matrix is also very important; the reduced form of manganese is more soluble and (bio-) available. Reducing conditions can create toxic Mn^{2+} levels in soils. Under more aerobic conditions, manganese precipitates out as sparingly soluble oxides, oxyhydroxides, and carbonates. Furthermore, manganese is strongly sorbed by organic matter, which also limits its mobility.

5.3.1.14 Mercury

Mercury was detected at concentrations above SVs in soil and groundwater (total phase only) samples from the Plant and Slag Pile Areas, and from sediment samples from the Slag Pile Area and the LVR at

OU1 (Table 4.3.1-1). Mercury was also detected at concentrations above SVs in building material, pile, soil, groundwater, and surface water samples (total phase only) at OU2 (Table 4.3.2-1).

Mercury mobility is strongly affected by pH, redox conditions, and chloride concentrations. Furthermore, mercury undergoes complexation with many organic and inorganic ligands in natural systems. Under acidic conditions and the presence of chloride, the poorly adsorbed mercury species HgCl_2 is the predominant form of mercury. Mercury is also strongly chelated by soil organic matter, which can either lead to immobilization, or to mobilization under conditions that favor the dissolution of organic matter (e.g., high pH conditions). Under low redox conditions, mercury may be immobilized by precipitation of mercury sulfides (e.g., cinnabar). However, under sulfate-reducing conditions, mercury may be methylated (methylmercury), which is the most toxic and bioaccumulative form of mercury.

5.3.1.15 Nickel

Nickel was detected at concentrations above SVs in sediment samples from the Slag Pile Area and the LVR, surface water samples (both total and dissolved phase) from the LVR, and in one groundwater sample (total phase only) from the Slag Pile Area at OU1 (Table 4.3.1-1). Nickel was detected at concentrations above SVs in building material and pile samples at OU2 (Table 4.3.2-1).

Nickel mobility is mainly governed by pH and its effect on potential sorption sites for nickel on oxides and oxyhydroxides of iron, manganese, and aluminum. The pH also influences the precipitation of nickel with other compounds, such as phosphates (e.g., at pH values greater than or equal to 7). Similar to copper and many other trace metals, organic matter has a high sorption capacity for nickel, which generally limits its mobility. However, in its dissolved form, organic matter (i.e., organic ligands) can also increase the leachability and transport of nickel. Under reducing conditions, nickel can form a variety of sparingly soluble sulfides that limit its mobility.

5.3.1.16 Selenium

Selenium was detected at concentrations above SVs in surface water samples from the LVR at OU1 (Table 4.3.1-1). Selenium was detected at concentrations above SVs in soil and groundwater samples at OU2 (Table 4.3.2-1).

Selenium (Se) is a naturally occurring, solid substance that is found in the Earth's crust. Selenium, in its pure form of metallic gray to black crystals, is often referred to as elemental selenium or selenium dust. Selenium is not often found in the environment in its elemental form, but is usually combined with other

substances. Selenium and its compounds are used in some photographic devices, gun bluing (a liquid solution used to clean the metal parts of a gun), plastics, paints, anti-dandruff shampoos, vitamin and mineral supplements, fungicides, and certain types of glass (ASTDR 2003).

Selenium commonly enters the air from burning coal or oil, though volcanic eruptions may release selenium in air. Selenium that may be present in fossil fuels combines with oxygen when burned, which may then react with water to form soluble selenium compounds. Airborne particles of selenium, such as in ash, can settle on soil or surface water (ASTDR 2003).

Selenium combines with metals and many nonmetals directly or in aqueous solution and it reacts with oxygen to form a number of oxides, the most stable of which is selenium dioxide. Selenium mobility is highly dependent on what compounds are formed. For example, elemental selenium that cannot dissolve in water and other insoluble forms of selenium are less mobile and will usually remain in the soil, posing smaller risk of exposure. The primary factor determining the fate of selenium in the environment is its oxidation state. Selenium is stable in four valence states (-2, 0, +4, and +6) and forms chemical compounds similar to those of sulfur.

The heavy metal selenides (Se^{-2}) are insoluble in water, as is elemental selenium. The inorganic alkali selenites (Se^{+4}) and selenates (Se^{+6}) are soluble in water and are therefore more bioavailable. Conditions such as pH, ORP, and the presence of metal oxides affect the partitioning of the various compounds of selenium in the environment. Sodium selenate is one of the most mobile selenium compounds in the environment because of its high solubility and inability to adsorb onto soil particles. Selenious acid (H_2SeO_3) is a weak acid, and the diselenite ion predominates in waters between pH 3.5 and 9, making it fairly mobile. Selenium is bioaccumulated by aquatic organisms and may also biomagnify in aquatic organisms (ASTDR 2003).

In soils, pH and ORP are determining factors in the transport and partitioning of selenium. Elemental selenium is essentially insoluble and may represent a major inert "sink" for selenium introduced into the environment under anaerobic conditions. Heavy metal selenides and selenium sulfides, which are also insoluble, predominate in acidic (low pH) soils and in soils with high amounts of organic matter and the form is immobile in soil. Sodium and potassium selenites (Se^{+4}) dominate in neutral, well-drained mineral soils, where some soluble metal selenites may be found as well. In alkaline (pH greater than 7.5), well-oxidized soil environments, selenates (Se^{+6}) are the major selenium species. Because of their high solubility and low tendency to adsorb onto soil particles, the selenates are very mobile and are readily taken up by biological systems or leached through the soil (ASTDR 2003).

5.3.1.17 Silver

Silver was detected at concentrations above SVs in sediment samples collected from the Slag Pile Area and the LVR, and in surface water samples from the LVR at OU1 (Table 4.3.1-1). Silver was detected at concentrations above SVs in surface water samples at OU2 (Table 4.3.2-1).

Silver (Ag) is one of the basic elements that make up our planet, which is found in the earth's crust. Silver is rare, but occurs naturally in the environment as a soft, "silver" colored metal. Silver occurs in powdery white (silver nitrate and silver chloride) or dark-gray to black compounds (silver sulfide and silver oxide). There are four oxidation states (0, 1+, 2+, and 3+); the 0 and 1+ forms are much more common than the 2+ and 3+ forms. Silver occurs primarily as sulfides, in association with iron (pyrite), lead (galena), and tellurides, and with gold. Silver is released into the atmospheric environment through anthropogenic activities, including, processing of ores, steel refining, cement manufacture, fossil fuel combustion, municipal waste incineration, and cloud seeding. Releases to surface water are primarily from photographic processing (ATSDR 1990).

Sorption is the dominant process controlling the partitioning of silver in water and movement in soil. Silver may leach from soil into groundwater; acidic conditions and good drainage increase the leaching rate. Silver is bioconcentrated to a moderate extent in fish and invertebrates (ATSDR 1990).

The transport and partitioning of silver in surface waters and soils is influenced by the particular form of the compound. Under oxidizing conditions the primary silver compounds would be bromides, chlorides, and iodides, while under reducing conditions the free metal and silver sulfide would predominate. Silver is more mobile under acidic and oxidizing conditions. In water, the major forms of silver are as the monovalent ion in the form of sulfate, bicarbonate, or sulfate salts; as part of more complex ions with chlorides and sulfates; and as an integral part of, or adsorbed onto, particulate matter. In soil, the mobility is affected by drainage (silver tends to be removed from well-drained soils); ORP and pH conditions (which influence the reactivity of iron and manganese complexes which tend to immobilize silver); and the presence of organic matter (which complexes with silver and reduces its mobility) (ATSDR 1990).

5.3.1.18 Thallium

Thallium was not detected at concentrations above SVs at OU1. Thallium was detected above SVs in soil, pile, groundwater, and surface water samples at OU2 (Table 4.3.2-1).

Thallium exists in water primarily as a monovalent ion (Tl^+); thallium may be trivalent (Tl^{3+}) in very oxidizing water (Callahan *et al.* 1979). Tl^+ forms complexes in solution with halogens, oxygen, and sulfur (Lee 1971). Thallium may precipitate from water as solid mineral phases. However, thallium chloride, sulfate, carbonate, bromide, and hydroxide are very soluble in water.

Thallium tends to sorb to aquifer materials and is more mobile under acidic conditions. At Site 7 of OU2, the pH of groundwater ranges from 6.6 to 7.6. Under these neutral conditions, thallium migration is limited. In addition to typical ion-exchange reactions with soils at those pH ranges, thallium is also subject to microbially-mediated precipitation reactions with sulfide at neutral to alkaline pH and redox potentials of -200 mV. Recent monitoring shows concentrations of thallium in groundwater are decreasing. This is likely due to either precipitation or sorption reactions between groundwater and the aquifer material.

5.3.1.19 Vanadium

Vanadium was detected at concentrations above SVs in one groundwater sample (total phase only) from the Plant Area, and one shallow soil sample from the Slag Pile Area at OU1 (Table 4.3.1-1). Vanadium was not detected at OU2.

The transport and partitioning of vanadium in water and soil is influenced by pH, redox potential, and the presence of particulate matter. The mobility of vanadium in soils is affected by the pH of the soil. Relative to other metals, vanadium is fairly mobile in neutral or alkaline soils, but its mobility decreases in acidic soils (Van Zinderen Bakker and Jaworski 1980), similar to arsenic and antimony. Under oxidizing, unsaturated conditions some mobility is observed, but under reducing, saturated conditions vanadium is immobile (Van Zinderen Bakker and Jaworski 1980).

In fresh water, vanadium generally exists in solution as the vanadyl ion (V^{4+}) under reducing conditions and the vanadate ion (V^{5+}) under oxidizing conditions, or as an integral part of, or adsorbed onto, particulate matter (Wehrli and Stumm 1989). The chemical formulas of the vanadyl species most commonly reported in fresh water are VO^{2+} and $VO(OH)^+$, and the vanadate species are $H_2VO_4^-$ and HVO_4^{2-} (Wehrli and Stumm 1989). The partitioning of vanadium between water and sediment is strongly influenced by the presence of particulate in the water. Both vanadate and vanadyl species are known to bind strongly to mineral or biogenic surfaces by adsorption or complexing (Wehrli and Stumm 1989). Thus, vanadium is transported in water in one of two ways: in solution or in suspension. It has been

estimated that only 13 percent is transported in solution, while the remaining 87 percent is in suspension (WHO 1988).

5.3.1.20 Zinc

Zinc was detected at concentrations above SVs in soil samples from the Plant and Slag Pile Areas, sediment samples from the Slag Pile Area and the LVR, groundwater samples (both total and dissolved phase) from the Plant and Slag Pile Areas, and surface water samples (both total and dissolved phase) from the LVR at OU1 (Table 4.3.1-1). Zinc was also detected at concentrations above SVs in building material, pile, soil (including SPLP soil samples), groundwater, and surface water samples (both total and dissolved phase) at OU2 (Table 4.3.2-1).

Zinc can combine with other elements, such as chlorine, oxygen, and sulfur, to form zinc compounds. Zinc compounds that may be found at hazardous waste sites are zinc chloride, zinc oxide, zinc sulfate, and zinc sulfide. Most zinc ore found naturally in the environment is in the form of zinc sulfide.

Zinc mobility and bioavailability is mainly governed by pH. As with many trace metals, zinc solubility is higher under more acidic conditions. Alkaline conditions favor adsorption of zinc to oxides and oxyhydroxides of iron, manganese, and aluminum, clay minerals and organic matter, and sorption and/or precipitation with carbonate minerals. Organic matter appears to play a more important role on zinc adsorption as compared to the hydroxides. Under low redox conditions, zinc may form insoluble sulfides. Naturally-occurring chelating agents, such as many organic acids, can increase the solubility and mobility of zinc.

5.3.2 VOCs

The VOCs present at OU1 and OU2 at concentrations above SVs were the following (Tables 4.3.1-1 and 4.3.2-1):

- 2-Butanone (MEK)
- Acetone
- Benzene
- Bromodichloromethane
- Cis-1,2-DCE
- Chloroform
- 1,2-Dichloroethane
- Ethylbenzene
- PCE
- TCE
- VC

Acetone, a potential laboratory artifact, was detected above SVs in sediment samples from the Slag Pile Area and the LVR at OU1. VC and 1,2-dichloroethane were detected at concentrations above SVs in groundwater samples from the Plant Area at OU1. Benzene, bromodichloromethane, chloroform, cis-1,2-DCE, ethylbenzene, PCE, TCE, and VC were detected at concentrations above SVs at OU2.

The key factors that influence the fate and transport of VOCs are their water solubility, volatility (e.g., vapor pressure and Henry's law constant), K_{OC} or K_{OW} , and K_d .

The solubilities of all VOCs at OU1 and OU2 are relatively high, suggesting that these COIs are mobile (Table 5.1-1). In addition, the Henry's law constants for all VOCs present at OU1 and OU2 are low ($<0.03 \text{ atm}\cdot\text{m}^3/\text{mol}$), suggesting volatilization is not anticipated to substantially influence the fate of these COIs (Table 5.1-1). Furthermore, the low K_d values suggest that the VOCs present at OU1 and OU2 do not have a strong tendency to partition in the organic matter in soil, and are therefore potentially mobile. Since all VOCs are present in groundwater, these COIs are mobile and may be transported through groundwater flows.

Volatilization is expected to be an important environmental fate process for 1,2-dichloroethane in soil and bodies of water. Biodegradation is expected to occur slowly in both water and soil surfaces. Hydrolysis and photolysis are not expected to be important fate processes, and the potential for bioconcentration in aquatic organisms appears to be low.

All VOC COIs may be degraded, but the degradation rate is expected to be very slow or limited for various reasons. Microbial biodegradation of chloroform occurs slowly and at low concentrations due to chloroform's toxicity. Microbial biodegradation of chloroform may also be inhibited due to high levels of other aromatics (e.g., toluene), chlorinated hydrocarbons (e.g., TCE), or heavy metals (e.g., zinc). In groundwater, chloroform is expected to persist for a long time.

Various studies have shown PCE to be resistant to biotransformation or biodegraded only slowly (Bouwer and McCarty 1982; Bouwer *et al.* 1981; Wakeham *et al.* 1983). Other screening studies have noted more rapid biodegradation; however, these studies used microbes that had to be adapted to PCE (Parsons *et al.* 1984, 1985; Tabak *et al.* 1981). Microbial degradation products of PCE in groundwater have been reported to include primarily TCE and small amounts of cis- and trans-DCE (Parsons *et al.* 1984, 1985; Smith and Dragun 1984). Biotransformation was strongly indicated as a factor in the degradation of PCE in a case of soil and groundwater pollution (Milde *et al.* 1988). The only ethenes at the source of

pollution were PCE and TCE; however, substantial amounts of known metabolites of these two compounds (DCE, VC, and ethene) were found at points far from the source.

Biodegradation of TCE is favored only under limited conditions. It has been shown that the biodegradation of TCE in soil increases with the organic content of the soil (Barrio-Lage *et al.* 1987). Degradation of TCE by anaerobes via reductive dehalogenation can be problematic because a common product is VC, a known carcinogen (Ensley 1991). Aerobic biodegradation of TCE occurs by cometabolism with aromatic compounds (Ensley 1991) and thus requires a cosubstrate such as phenol (Nelson *et al.* 1987, 1988) or toluene (Fan and Scow 1993).

Degradation of VC generally occurs slowly in anaerobic groundwater and sediment; however, under methanogenic or Fe(III) reducing conditions anaerobic degradation occurs more rapidly. VC was mineralized approximately 34 percent in 84 hours in anaerobic aquifer microcosms supplemented with Fe(III) and held under Fe(III) reducing conditions (Bradley and Chapelle 1996).

Acetone (also dimethyl ketone, 2-propanone, and beta-ketopropane) is a manufactured chemical that is also found naturally in the environment. It is a colorless liquid with a distinct smell and taste. Acetone evaporates easily, is flammable, and dissolves in water. Acetone is used to make plastic, fibers, drugs, and other chemicals. It is also a common solvent. Acetone occurs naturally in plants, trees, volcanic gases, forest fires, and as a product of the breakdown of body fat. It is present in vehicle exhaust, tobacco smoke, and landfill sites. Industrial processes contribute more acetone to the environment than natural processes.

A large percentage (97 percent) of the acetone released during its manufacture or use goes into the air. In air, about one-half of the total amount breaks down from sunlight or other chemicals every 22 days. It moves from the atmosphere into the water and soil by rain and snow. It also moves quickly from soil and water back to air. Acetone does not bind to soil or bioaccumulate in animals. Acetone is easily degraded by microorganisms in soil and water, but the time required for this to happen varies. Acetone is mobile and can move into groundwater from spills or landfills, though a portion of the acetone will volatilize (Howard 1990).

Benzene, also known as benzol, is a colorless liquid with a sweet odor. Benzene evaporates into air very quickly and is soluble in water. Benzene is highly flammable. Benzene is released to the environment by both natural and industrial sources, although the anthropogenic emissions are the most significant. Emissions of benzene to the atmosphere result from gasoline vapors, auto exhaust, and chemical

production and user facilities. Benzene is released to water and soil from industrial discharges, landfill leachate, and gasoline leaks from underground storage tanks.

Benzene released to soil or waterways is subject to volatilization, photooxidation, and biodegradation. Biodegradation, principally under aerobic conditions, is an important environmental fate process for water- and soil-associated benzene. The high volatility of benzene is the controlling physical property in the environmental transport and partitioning of this chemical. Benzene is considered to be highly volatile with a vapor pressure of 95.2 mm Hg at 25 °C. Benzene is soluble in water, with a solubility of 1,780 mg/L at 25 °C, and the Henry's law constant for benzene (0.0055 atm-m³/mole at 25 °C) indicates that benzene partitions readily to the atmosphere from surface water (Mackay and Leinonen 1975).

Benzene released to soil surfaces partitions to the atmosphere through volatilization, to surface water through runoff, and to groundwater as a result of leaching. The organic carbon sorption coefficient (K_{oc}) for benzene has been measured with a range of 60 to 83 (Karickhoff 1981; Kenaga 1980), indicating that benzene is highly mobile in soil and readily leaches into groundwater. Other parameters that influence leaching potential include the soil type (e.g., sand versus clay), amount of rainfall, depth of the groundwater, and extent of degradation.

Bromodichloromethane is a colorless, heavy, noncombustible liquid. Bromodichloromethane is not produced or used on large commercial scale, instead the predominant release to the environment results from inadvertent formation during water chlorination (Howard 1990). It is formed as a by-product when chlorine is added to drinking water to kill disease causing organisms (ATSDR 1989).

Bromodichloromethane has a Henry's law constant of 0.0016 atm- m³ /mol at 20°C and a vapor pressure of 50 mmHg at 20°C. Volatilization is likely to be the dominant environmental fate process of bromodichloromethane due to the high vapor pressure and Henry's Law constant.

Bromodichloromethane is soluble with a solubility of 4,700 mg/L at 20°C. The estimated volatilization half-life of bromodichloromethane from rivers and streams ranges from 33 minutes to 12 days, with a typical half-life of approximately 35 hours (Howard 1990).

If bromodichloromethane is released to soil it will be subject to volatilization. In soil, the relatively low log octanol-water partition coefficient (K_{ow}), 2.10, indicates that adsorption is not likely to be a dominant factor (ATSDR 1989). The reported and estimated K_{oc} values (ranging from 53 to 251) indicate that bromodichloromethane is expected to be moderately to highly mobile in soil and leach into groundwater.

Bromodichloromethane undergoes significant biodegradation with gradual adaptation, with approximately 50 percent loss of bromodichloromethane in a 28 day test (Howard 1990).

Ethylbenzene is a colorless liquid with an aromatic odor. Ethylbenzene is released into the environment in atmospheric emissions and wastewater releases during its production and use in the manufacture of styrene and use as a solvent. Other sources include emissions from petroleum refining, vaporization losses and spills of gasoline and diesel fuel at filling stations and during storage and transit of these fuels, auto emissions, and cigarette smoke (Howard 1989).

The Henry's law constant value of $0.00844 \text{ atm} \cdot \text{m}^3 / \text{mol}$ at 20°C suggests that ethylbenzene evaporates readily to the atmosphere from surface water. From the Henry's law constant the half-life for volatilization for ethylbenzene from a rapidly moving, shallow river (1 meter deep, flowing 1 meter per second, with a wind velocity of 3 meters per second) is estimated to have a half-life of 3.1 hours.

Ethylbenzene is soluble in water, with a solubility of 161 mg/L at 25°C (Howard 1989).

Ethylbenzene is removed from the atmosphere principally through reaction with photochemically generated oxygenated species (e.g., hydroxyl radicals). When released to surface water, volatilization is expected to be the primary fate process. When released to soil, part will evaporate, part will moderately absorb to the soil, but most will likely leach into the groundwater and become a groundwater contaminant. Based on K_{oc} value of 164 ml/g, ethylbenzene is classified as having moderate mobility in soils (Howard 1989). Sorption and retardation by soil organic carbon content will occur to a moderate extent, but sorption is not significant enough to completely prevent migration in most soils. Particularly in soils with low organic carbon content, ethylbenzene will tend to leach into groundwater. Mobility is also possible in aquifers that contain very little solid-phase organic matter, a condition common to sand and gravel aquifers (ATSDR 2007). Releases of ethylbenzene into water will decrease in concentration by evaporation and biodegradation. The time for this decrease and the primary loss processes will depend on the season, and the turbulence and microbial populations in the particular body of water. Representative half-lives are several days to two weeks. Ethylbenzene has little to no tendency to bioaccumulate in plants or animals and it has a BCF of 1.19 in goldfish (Howard 1989).

Xylenes are also known as xylol or dimethylbenzene, are primarily synthetic chemicals. There are three aromatic hydrocarbon isomers of xylene. These are ortho-xylene (or o-xylene), meta-xylene (or m-xylene), and para-xylene (or p-xylene). Chemical industries produce xylenes from petroleum. Xylenes also occur naturally in petroleum and coal tar and are formed during forest fires. It is a colorless,

flammable liquid with a sweet odor. Xylenes are primarily used as solvents in the printing, rubber, and leather industries.

Based on Henry's law constants of 0.005 to 0.007 atm-m³/mol (Foster et al. 1994; Sanemasa et al. 1982), volatilization is expected to be the dominant transport mechanism for xylenes in surface water. The half-life associated with the volatilization of o-xylene from surface waters at a depth of one (1) meter is reported to be 5.6 hours (Mackay and Leinonen 1975). This value will vary in accordance with turbulence and water depth. Once xylenes enter the atmosphere, they undergo rapid photooxidation such that washout and long-range atmospheric transport are not expected to be important processes.

Soil organic carbon sorption coefficient (K_{oc}) values ranging from 25.4 to 540 indicate that xylenes are mobile in soil and will not adsorb strongly to organic matter, although adsorption does increase with increasing organic matter (Green et al. 1981; Kango and Quinn 1989; Nathwani and Phillips 1977; Seip et al. 1986; Swann et al. 1983). Based on the Henry's law constants and vapor pressures (6.6 to 8.8 mm Hg) (AIChE 1996; Chao et al. 1983; Lewis 2000), xylenes that are released to soil are expected to volatilize if near the surface. However, the mobility of xylenes in soil indicates that these substances may also leach into groundwater, especially when volatilization is hindered as is the case with underground releases from gasoline storage tanks.

5.3.3 SVOCs

The COIs present at OU1 and OU2 above SVs that are SVOCs were the following (Table 4.3.1-1 and 4.3.2-1):

- Acenaphthene
- Acenaphthylene
- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Bis(2-ethylhexyl)phthalate
- Carbazole
- Chrysene
- Dibenzo(a,h)anthracene
- Fluoranthene
- Hexachlorobenzene
- Indeno(1,2,3-cd)pyrene
- Naphthalene
- Phenanthrene
- Pyrene

The following SVOCs were detected at concentrations above SVs in soil, sediment and groundwater samples from the Slag Pile Area, the Plant Area and the LVR at OU1:

- Acenaphthene
- Acenaphthylene
- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Carbazole
- Chrysene
- Dibenzo(a,h)anthracene
- Indeno(1,2,3-cd)pyrene
- Bis(2-ethylhexyl)phthalate

The following COIs were detected at concentrations above SVs at OU2:

- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Bis(2-ethylhexyl)phthalate
- Chrysene
- Dibenzo(a,h)anthracene
- Fluoranthene
- Indeno(1,2,3-cd)pyrene
- Naphthalene
- Phenanthrene
- Pyrene

The key factors that influence the fate and transport of SVOCs are their water solubility, volatility (e.g., vapor pressure and Henry's law constant), K_{OC} or K_{OW} , and K_d . This section provides a description of the general behavior of SVOCs.

All of the SVOC COIs in OU1 and OU2 are expected to be strongly adsorbed by soils or sediments. The K_d values of all but four SVOC COIs in OU1 and OU2 are high (greater than 300 mL/g), suggesting that adsorption is likely to limit the migration of these compounds (Table 5.1-1). The SVOC COIs with K_d values less than 300 mL/g were acenaphthene, acenaphthylene, carbazole, fluoranthene, naphthalene, phenanthrene, and pyrene (Table 5.1-1). The sampling results show that SVOCs that were measured at concentrations above SVs were found in soil and sediment samples and not groundwater or surface water samples, with the exception of bis(2-ethylhexyl)phthalate and naphthalene, which were present at concentrations above SVs in groundwater samples (Tables 4.3.1-1 and 4.3.2-1).

A subset of SVOCs investigated at the Site includes polycyclic aromatic hydrocarbons (PAHs). PAHs that were detected at concentrations above SVs at OU1 and OU2 include the following:

- Acenaphthene
- Acenaphthylene
- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Carbazole
- Chrysene
- Dibenzo(a,h)anthracene
- Fluoranthene
- Indeno(1,2,3-cd)pyrene
- Naphthalene
- Phenanthrene
- Pyrene

PAHs are composed of hydrogen and carbon arranged in the form of two or more fused benzene rings in linear, angular, or cluster arrangements, which may or may not have substituted groups attached to one or more rings (Eisler 1987). Low molecular weight PAHs (e.g., 128.16 for naphthalene) are more mobile in the environment as compared to the high molecular weight PAHs (e.g., 252.3 for benzo(a)pyrene). Higher molecular weight PAHs are relatively immobile because of their large molecular volumes and their extremely low volatility and solubility. The lower molecular weight unsubstituted PAH compounds containing two to three rings, such as fluorenes and anthracenes, have significant acute toxicity to some organisms, whereas the higher molecular weight four- to seven-ring aromatics do not.

In aquatic environments, PAHs tend to sorb to suspended particles or sediments. The degree of sorption depends on the organic carbon content and particle size (ATSDR 1997). Sorption of PAHs to particulates increases with increasing organic carbon content of the particles and increasing molecular weight of the PAHs. Low and medium molecular weight PAHs are more likely to be transported through sediments by leaching or to be resuspended into the water column. At low humic acid concentrations (below 0.1 percent), hydrocarbons are adsorbed onto the hydrophobic portions of humic particles (Eisler 1987). This sorption increases as the humic acid concentration increases. Above humic concentrations of 0.1 percent, solubilization of PAHs into humic acid aggregates sharply increases. This solubility is also pH dependent. At a humic acid concentration of 0.05 percent, higher pH levels favor PAH solubilization. Approximately 33 percent of PAHs do, however, remain dissolved in the water column (Eisler 1987). These PAHs are expected to degrade rapidly through photo oxidation (if exposed to sunlight).

In general, the high number of aromatic rings and molecular weight of SVOCs and PAHs results in low water solubility and high K_{oc} (Table 5.1-1). The high K_{oc} values indicate a strong tendency for the compound to partition in the organic matter in soil, resulting in lower mobility. With most K_d values ranging from 100 to 12,600, even the most water-soluble SVOCs would not be readily mobile in the dissolved phase. Therefore, PAHs are not expected to be mobile in groundwater or surface waters. One exception is naphthalene, which is soluble in water and has lower K_{oc} and K_d values than other SVOCs (Table 5.1-1).

In soils, PAHs do not readily volatilize, and are typically adsorbed strongly to soil and soil organic matter. PAHs are therefore expected to remain adsorbed to soil at the Site. Concentrations of PAHs in soil typically tend to decrease over time as a result of natural attenuation processes such as degradation and dispersion. PAHs undergo biodegradation in both soil and water; however, they tend to bioaccumulate in plant and animal tissue.

The lack of mobility is further illustrated by the number and distribution of SVOCs in soil that were measured at concentrations above SVs compared to the sporadic, low number of samples measured at concentrations above SVs in groundwater (Table 4.3.1-1). All SVOCs (except bis(2-ethylhexyl)phthalate and naphthalene) were detected at concentrations above SVs in soil and/or sediment samples. Although bis(2-ethylhexyl)phthalate was detected at concentrations above SVs in groundwater samples, it is expected to have a low mobility in groundwater and is expected to easily biodegrade due to its high affinity for organic carbon in soil (high K_{oc} value) (Table 5.1-1). Naphthalene was detected in soil and groundwater samples at OU2. Naphthalene is easily volatilized from aerated soils (Park *et al.* 1990) and is adsorbed to a moderate extent (10 percent) (Karickhoff 1981; Schwarzenbach and Westall 1981). The extent of sorption depends on the organic carbon content of the soil, with rapid movement expected through sandy soils (Howard 1989). Because it adsorbs to aquifer material (Ehrlich *et al.* 1982), the passage of naphthalene through groundwater will be somewhat retarded. Naphthalene is expected to have low mobility as it is likely to remain adsorbed to sediments or particulate matter, however a small fraction may be transported in groundwater.

5.3.4 PCBs

The COIs present at OU1 and OU2 above SVs that are PCBs were the following (Table 4.3.1-1 and 4.3.2-1):

- Aroclor 1242
- Aroclor 1248
- Aroclor 1254
- Aroclor 1260

Aroclor 1242 was detected at concentrations above SVs in sediment samples from the LVR at OU1 (Table 4.3.1-1). Aroclor 1242 was not detected at concentrations above SVs at OU2. Aroclor 1248 was not detected at concentrations above SVs at OU1. Aroclor 1248 was detected at concentrations above screening levels in soil, pile, and groundwater samples at OU2 (Table 4.3.2-1). Aroclor 1254 was detected at concentrations above SVs in soil samples from the Plant Area sediment samples from the Slag Pile and the LVR at OU1 (Table 4.3.1-1). Aroclor 1254 was also detected above SVs in pile, soil, and groundwater samples at OU2 (Table 4.3.2-1).

Aroclor 1260 was detected at concentrations above SVs in soil samples from the Plant Area and a sediment sample from the Slag Pile (area impacted by seep from OU2) and the LVR at OU1 (Table 4.3.1-1). Aroclor 1260 was also detected at concentrations above SVs in building material, pile, and soil samples at OU2 (Table 4.3.2-1).

PCBs are a general class of chemically-inert, non-polar, synthetic, halogenated hydrocarbons, of which there are 209 different compounds (congeners) (Eisler and Belisle 1996). Congeners differ based on the number of chlorine atoms substituted on the biphenyl ring; between one and ten substitutions are possible. As a group, PCBs in the environment are insoluble, stable, persistent, and lipophilic with log K_{OW} values that range from 4.15 to 9.60 (Eisler and Belisle 1996). Generally, log K_{OW} values increase with increasing chlorination, and higher log K_{OW} values indicate higher hydrophobicity and binding affinity. The first two digits of each Aroclor compound generally refer to the number of carbon atoms in the biphenyl skeleton (for PCBs this is 12), the second two numbers indicate the percentage of chlorine by mass in the mixture.

PCBs strongly adsorb to soils and sediments; however, in the presence of organic solvents, PCBs have a tendency to leach through soil to groundwater. Although they may be strongly adsorbed to soil or sediments for long periods of time, dissolution to the water column has also been shown to occur. In

aquatic environments, PCBs rapidly partition to organic carbon phases in the water column and sediment, and lipid fractions in biota. Therefore, less chlorinated congeners tend to be transported by the water column sorbed to the suspended and dissolved organic phases while more highly chlorinated congeners sorb more readily to sediment organic carbon. Lower chlorinated congeners may also volatilize to the atmosphere depending primarily on wind speed and water column concentration. PCBs bound to sediment particles are persistent; however, minor transformation processes such as volatilization, photo-oxidation, hydrolysis and metabolism (dechlorination) by both aerobic and anaerobic microorganisms do occur. PCBs have high bioconcentration factors, and due to lipophilicity, especially of highly chlorinated congeners, tend to accumulate in the fat of fish, birds, mammals, and humans (ATSDR 1995).

All PCBs are expected to have low mobility as they are likely to remain adsorbed to sediments or particulate matter in soil. All PCBs have low water solubility, and high K_{OW} values (Table 5.1-1). All PCBs are generally resistant to biodegradation, but will biodegrade over time in soil and water systems. Minimal leaching of PCBs to groundwater is expected, unless organic solvents are present.

5.3.5 Pesticides

The COIs present at OU1 and OU2 above screening levels that are pesticides were the following (Tables 4.3.1-1 and 4.3.2-1):

- 4,4'-DDD
- 4,4'-DDT
- Aldrin
- Alpha-BHC
- Alpha-chlordane
- Beta-BHC
- Delta-BHC
- Dieldrin
- Endrin
- Endrin aldehyde
- Gamma-chlordane
- Heptachlor
- Heptachlor epoxide

Concentrations of pesticides above SVs were measured in sediment samples from the LVR at OU1 (Table 4.3.1-1). Pesticides were also detected above SVs in pile samples, groundwater samples and surface water samples collected from OU2 (Table 4.3.2-1). Aldrin, alpha/beta/delta-BHC, alpha-chlordane, dieldrin, heptachlor, and heptachlor epoxide were detected at concentrations above SVs at OU2 (Table 4.3.2-1).

The key factors that influence the fate and transport of pesticides are their water solubility, volatility (e.g., vapor pressure and Henry's law constant), K_{OC} , or K_{OW} . This section provides a description of the predicted fate and transport of the aforementioned pesticides.

The detected pesticides belong to a chemical class (organochlorine [OCL] pesticides) that is generally more strongly sorbed to soil and sediment compared to most other organic constituents classes. As a result, OCL pesticides are generally found close to the surface in the near vicinity of their original release point.

These compounds may be reduced through a hydrogenolysis reaction where the carbon-halogen bonds are broken and a carbon-hydrogen bond is made in its place. Thus, OCL pesticides tend to be present in oxygen-rich environments where reduction is less likely. Many of the OCL pesticides (4,4'-DDD, 4,4'-DDE, Delta-BHC, have benzene ring structures that make them susceptible to photodegradation under many environmental conditions (Lehr 2000). DDT is converted to DDD through a detoxifying reaction by microorganisms. DDE may also be present in the absence of this detoxifying reaction as it makes up ~1 percent of the commercial mixture of DDT. Pesticides are not generally known for their volatilization potential, although some pesticides do volatilize at environmentally significant rates. For example, heptachlor has a Henry constant of 8×10^{-4} atm-m³/mol (US EPA 1996), which is 80 times above US EPA Region 9's rule of thumb threshold for pesticides generally of 1×10^{-5} atm-m³/mol (US EPA 1998).

Aldrin is a chlorinated hydrocarbon that is most frequently used as an insecticide. Pure grade aldrin is a white powder, while technical grade aldrin is a tan powder, both forms have a mild chemical odor (NIOSH 2004; ATSDR 2002a). Aldrin has a K_{oc} of 9,600 mL/g, and therefore, binds tightly into a soil matrix (LaGrega 1994). Dieldrin's vapor pressure is 6.0×10^{-6} mmHg at 25°C and it is considered non-volatile, as it will evaporate very slowly into the air (LaGrega 1994). Aldrin is chemically very similar to dieldrin. Aldrin is a very strong organic pollutant and is not known to degrade in nature, though sunlight and bacteria in the environment can change aldrin to dieldrin. Therefore, you can find dieldrin in places where aldrin was originally released. Dieldrin persists because it is more resistant to biotransformation and abiotic degradation than aldrin. As a result, it is found in all environmental media, even at a distance from the Site of concentration (ATSDR 2002). Aldrin has a potential to bioaccumulate in plants and animals and has a BCF of 3,140 L/kg in fish (ATSDR 2002). Aldrin is immobile in soils due to strong partitioning to soil organic matter and soil particulates and transport is minimal. Aldrin has a very low solubility (0.18 mg/L at 25°C) and is not expected to exist in groundwater (LaGrega 1994).

Alpha-, beta- and delta-BHC (also referred to as hexachlorocyclohexanes) are halogenated organic compounds that were formerly used as insecticides. Each compound is an isomer of the insecticide Lindane, which was used as a farming insecticide and to treat head and body lice until 1976 when it was banned in the United States (ATSDR 2005). Alpha-BHC is a brownish to white, crystalline solid with a phosgene-like odor; beta-BHC is a crystalline solid; and delta-BHC is a white crystal or fine platelet, with a slightly musty odor (ATSDR 2005). Solubilities for the three isomers range from 5 to 69.5 mg/L (Table 5.1-1) (ATSDR 2005). Delta-BHC is moderately soluble with a solubility of 10 mg/L at 25°C, and adsorption to sediments/soils is not predicted to be strong based on the K_{OW} , K_{OC} and K_d values (Table 5.1-1). Vapor pressures for alpha-, beta-, and delta-BHC are 4.5×10^{-5} mmHg at 25°C, 3.6×10^{-7} mmHg at 20°C, and 3.5×10^{-5} mmHg at 25°C, respectively, and they are considered non-volatile, as they will evaporate very slowly into the air (ATSDR 2005).

Chlordane (including alpha and gamma-isomers) and endrin (including aldehyde and ketone-isomers) have a low solubility in water, a low vapor pressure, and are not readily volatile from water (see Chemical Properties in Table 5.1-1). Both pesticides have very high K_{OC} and K_{OW} values which dictate sorption as the primary process governing the fate of these constituents in soil or water. Hydrolysis, oxidation, direct photolysis, and biodegradation are not expected to be significant transformation processes though endrin will react with photochemically produced hydroxyl radicals in the atmosphere (Howard 1990).

Dieldrin was detected in pile samples at OU2. Dieldrin is a metabolic byproduct of aldrin; dieldrin is more persistent and resistant to biodegradation than aldrin. Dieldrin has a K_{OC} of 1,700 mL/g, and therefore, binds tightly into a soil matrix (LaGrega 1994). The vapor pressure for dieldrin is 1.78×10^{-7} mm Hg at 20°C and it is considered non-volatile, as it will evaporate very slowly into the air (LaGrega 1994). It is a very strong organic pollutant and is not known to degrade in nature. Dieldrin has a strong potential to bioaccumulate in plants and animals (ATSDR 2002 and LaGrega 1994). Dieldrin is expected to be immobile in soils due to strong partitioning to soil organic matter and soil particulates. Dieldrin has a very low solubility (0.11 mg/L at 25°C) and is not expected to exist in groundwater (LaGrega 1994). Dieldrin has not been detected in groundwater to date in OU2 groundwater. The dieldrin detected in the OU2 pile samples is expected to have low mobility as it is likely to remain adsorbed to particulate matter.

Heptachlor was detected in surface water samples at OU2. Heptachlor has a log K_{OC} of 4.34 mL/g, and therefore, moderately binds to soils and should not be highly mobile (LaGrega 1994 and Exttoxnet 1996). The vapor pressure of heptachlor is 3.0×10^{-4} mm Hg at 25°C and it is considered non-volatile, as it will evaporate very slowly into the air (LaGrega 1994). It is a very strong organic pollutant and is not known to degrade in nature. In water, heptachlor readily undergoes hydrolysis to a compound which is then

readily processed (preferentially under anaerobic conditions) by microorganisms into heptachlor epoxide ([Section 5.3.5](#)). After hydrolysis, volatilization, adsorption to sediments, and photodegradation may be significant routes for disappearance of heptachlor from aquatic environments (Exttoxnet 1996).

Heptachlor has a strong potential to bioaccumulate in plants and animals (LaGrega 1994). Heptachlor has a very low solubility (0.05 mg/L at 25°C) and is not expected to exist in groundwater (LaGrega 1994).

Heptachlor epoxide was detected in groundwater samples at OU2. Heptachlor epoxide is an OCL compound that is a breakdown product of heptachlor. Heptachlor epoxide is more stable than its parent compound heptachlor and more persistent in the environment. Heptachlor epoxide has a log K_{OC} of 3.34 to 4.37 mL/g, and therefore, moderately binds to soils and should not be highly mobile (LaGrega 1994 and Exttoxnet 1996). Heptachlor epoxide is more likely to be found in the environment than its parent compound, heptachlor. Heptachlor epoxide is significantly more persistent than its parent compound, heptachlor. Heptachlor epoxide has a low solubility of 0.275 mg/L at 25°C (LaGrega 1994). Heptachlor and its epoxide absorb to soil particles and evaporate. Heptachlor epoxide is moderately bound to soil and should not be highly mobile (Exttoxnet 1996). The vapor pressure of heptachlor epoxides is 3.0×10^{-4} mm Hg at 25°C and it is considered non-volatile, as it will evaporate very slowly into the air (LaGrega 1994). It is a very strong organic pollutant and is not known to degrade in nature. Heptachlor epoxide is not very susceptible to biodegradation, photolysis, oxidation, or hydrolysis in the environment (Exttoxnet 1996). Heptachlor has a strong potential to bioaccumulate in plants and animals (LaGrega 1994).

5.3.6 Asbestos

Asbestos was not detected at OU1. Asbestos was detected in soil, building material, and pile samples at OU2 (Table 4.3.2-1). Asbestos is expected to have low mobility as it is likely to remain intact as particulate matter, however a small fraction may be transported via air or surface water runoff.

Asbestos in former building materials, debris, or soil will likely be transported either via air (wind) or surface water runoff. The fibers are not chemically bound to any substrate so they are readily released into air or flowing runoff water. However, fibers in soil in the subsurface tend to be immobile based on the physical position in the soil matrix.

In aquatic environments asbestos can be transported as a particulate in surface water flows. Asbestos fibers tend to adhere to soil particles in the ground and not be transported with groundwater flow. Mineral fibers are relatively stable and tend to persist under typical environmental conditions. However, asbestos fibers may undergo chemical alteration as well as changes in dimension. For example,

chrysotile, and to a lesser extent amphibole, asbestos fibers are capable of chemical alteration in aqueous media. The magnesium hydroxide content of chrysotile is partially or wholly removed by solution, depending on time, temperature, and pH. An insoluble silica skeleton of the fiber remains. Grunerite fibers, of which amosite is the known commercial form, have been reported to react with water, losing some iron on extended exposure to surface water; the fibers appeared partially degraded and broken when examined microscopically (WHO 1986).

Asbestos fibers are frequently transported in the air. Airborne mineral fibers are stable and may travel significant distances from the Site of origin. Airborne asbestos fibers, for example, have aerodynamic diameters that are generally less than 0.3 μm and, therefore, their sedimentation velocities are very low (WHO 1986). The greatest health risks are caused by asbestos fibers that are inhaled.

5.4 POTENTIAL CONTAMINANT MIGRATION ROUTES FOR OU1

The following sections discuss the potential migration of COIs in soil, groundwater, air, surface water runoff, surface water, and sediment at OU1.

5.4.1 Potential Migration of Inorganic Contaminants in Soil

The COIs that were detected in soil samples from OU1 at concentrations above SVs included the following:

- | | | |
|------------|-------------|------------|
| • Antimony | • Copper | • Mercury |
| • Arsenic | • Iron | • Vanadium |
| • Cadmium | • Lead | • Zinc |
| • Cobalt | • Manganese | |

The likely migration route of these COIs is from the soil to the groundwater. Other than fugitive dust generation, migration of these COIs to the air is unlikely as the COIs listed above are not volatile.

Erosion and transport in surface water is addressed in [Section 5.4.4](#).

The mobility of the aforementioned inorganic COIs in soil to the groundwater is dependent upon soil chemistry conditions (e.g., soil pH, redox, presence of dissolved organic matter or metal oxides). Soluble forms of all the aforementioned inorganic COIs are relatively mobile, but other forms may adsorb to sediments or soils. The redox conditions in the soil may also have an important role in dictating the mobility of most of the inorganic COIs as described above. Those inorganic COIs observed in soil samples which were also observed in the dissolved fraction of the groundwater samples and in excess of

screening criteria (arsenic, cadmium, cobalt, iron, lead, manganese, selenium, and zinc), indicates that these COIs have mobilized to the groundwater ([Section 4.1.3](#) and Figures 4.1.3-1 to 4.1.3-6).

Additional analyses (i.e., SEP, SPLP, specialized leachability testing, and TCLP) were performed on soil and sediment samples to better predict the fate and transport of select inorganic COIs (metals). These tests and results are discussed [Sections 5.4.1.1](#) through [5.4.1.4](#).

5.4.1.1 SEP Results

SEPs were performed for select metals on soil samples collected in 2007 and 2009. Samples submitted for SEP analyses were collected from clay/alluvium, fill/till, and terrestrial slag (slag in upland areas), and submerged slag (slag within the LVR).

The SEP consisted of seven extractions to characterize the partitioning of inorganic compounds among different soil fractions. The extracting solutions of the SEP are used to target inorganic compounds that may be immobilized or mobilized by a particular mechanism (e.g., adsorption onto different mineral phases or precipitation) or otherwise associated with a particular soil phase (e.g., organic matter). Investigation of the inorganic compounds associated with these different soil phases provides important information on how these inorganic compounds may be geochemically attenuated. Knowledge of where a particular metal is associated in the solid phase through the SEP may also be used to investigate the geochemical processes that may result in mobilization if Site conditions were to change (e.g., changed land use, and/or spills or releases of other chemicals to the soil that result in a change in the soil geochemical environment). There are any number of extraction solutions and order of extractions documented in the scientific literature. The seven-step SEP utilized by the laboratory during the 2009 sediment sampling and analysis program were as follows:

- Step 1 - Exchangeable Fraction (F1): This extraction targets inorganic compounds that are reversibly adsorbed to soil minerals, amorphous solids, and/or organic material by electrostatic forces. The extraction involves exposing the soil sample to a concentrated electrolyte solution, such as 1 molar (M) magnesium sulfate, that displaces the trace elements from solid surfaces. A significant fraction of inorganic compounds in the exchangeable fraction is of concern because the inorganic compound is weakly bound and is therefore readily displaced (*i.e.*, returned to solution in groundwater) by other, less toxic cations or anions.
- Step 2 - Carbonate Fraction (F2): This extraction targets trace elements that are adsorbed or otherwise bound to carbonate minerals. The test involves extraction with a weak acid solution (1

M sodium acetate solution in 25 percent acetic acid at pH 5). By lowering the pH from neutral conditions to pH 5, bicarbonates are converted to carbonic acid, thereby liberating bicarbonate-bound metals. Carbonate minerals are generally more stable than electrostatically-driven adsorption. Inorganics bound to this fraction may be liberated or mobilized by the infiltration of low pH rainwater or via contact with low pH groundwater.

- Step 3 – Non-Crystalline Materials Fraction (F3): This extraction targets trace elements that are complexed by amorphous minerals (e.g., iron). This fraction is extracted with 0.2 M ammonium oxalate (pH 3). Inorganic compounds present in this fraction are more strongly bound relative to inorganic compounds extracted in Steps 1 and 2. However, the inorganic may be mobilized if the soil becomes reducing which may affect the stability of the iron and other poorly-formed mineral that have immobilized arsenic.
- Step 4 - Metal Hydroxide Fraction (F4): This extraction targets inorganic compounds bound to crystalline hydroxides of iron, manganese, and aluminum. In this step, metals are extracted using a solution of 1 M hydroxylamine hydrochloride in 25 percent volume to volume acetic acid. This strong reductant reaction reduces iron (III) to iron (II). Like Step 3, this extraction targets inorganic compounds that may be mobilized if the soil or groundwater becomes reducing. However; inorganic compounds associated with the crystalline metal hydroxide phase are generally more stable than inorganic compounds associated with amorphous minerals (Step 3).
- Step 5 - Organic Fraction (F5): This extraction step targets inorganic compounds that are strongly bound via chemisorption to organic material. Oxidation of soil organic matter (using an extractant at pH 9.5; at 5 percent sodium hypochlorite), will mobilize inorganic compounds previously bound to organic functional groups. This extraction provides an estimate of the mass of an inorganic that may be mobilized by a geochemical conditions where the soil or groundwater becomes oxidizing (e.g., addition of an oxidant, dredging reduced sediments and placing the spoils on land where they are exposed to air).
- Step 6 - Acid/Sulfide Fraction (F6): This extraction is used to investigate trace elements precipitated as sulfide minerals, an important immobilization mechanism for many inorganic compounds in reduced soil and groundwater. Metals associated with sulfide minerals are extracted by leaching the soils with a 3:1:2 volume to volume solution of hydrochloric acid, nitric acid, and water to dissolve the metal sulfide minerals. Like Step 5, this is an oxidative step; however, this extraction is performed at a lower pH.
- Step 7 - Residual Fraction (F7): Trace elements remaining in the soil after the previous extractions will be distributed between silicates, phosphates, and refractory oxides. These

residual metals can be removed from the soil through total dissolution with hydrofluoric acid, nitric acid, hydrochloric acid, and boric acid. This step quantifies the residual inorganic compounds remaining after the previous extractions.

During 2007, analyses of soil submitted to the laboratory for SEP extraction and analyses was performed using the same seven SEP extractions with a change in the extraction order. For soil samples, the organic fraction was extracted and analyzed after the exchangeable fraction (Step 2) instead of after Step 5, as performed in 2009 and summarized above. Though there are multiple methods and extraction orders for SEP documented in the scientific literature that incorporate targeting of the organic fraction earlier and/or later in the SEP, the organic fraction was targeted as a latter step in the 2009 sampling and analysis program due to the strength of the extracting solution and consistency with the more commonly utilized SEP approaches. The most mobile inorganic compounds are extracted during the first SEP steps and the less mobile inorganic compounds are extracted in the last SEP steps. The last extraction of the SEP (Step 7 – Residual Fraction) targets inorganic compounds that are very strongly bound to soil. An extracting solution that is more destructive than a total metals analysis is used to extract inorganic compounds bound in this fraction. Consequently, the total concentration calculated by summing the mass extracted at each step of the SEP is generally higher than the mass extracted by a separate total metal analysis. But, this will not always be the case, due to dilutions at each step of the SEP and natural variability in the concentration of different samples.

It should also be noted that each of the extractions in the SEP are “operationally-defined.” Consequently, metals that are mobilized from a specific extraction step may result in chemical reactions not evaluated by the extraction. For instance, during Step 2 (carbonate extraction) arsenic extracted from the soil may include inorganic compounds from poorly crystalline minerals that are unstable when exposed to a pH 5 extracting solution.

The SEP results are summarized by media in Table 5.4.1-1. The average SEP results were calculated by media type for each inorganic compound, and the relative fractions are summarized in Table 5.4.1-2. The following subsections provide a review of SEP results for select metals in these media.

Inorganic Specific Analyses

Comparisons of individual metals fractionation in clay/alluvium, fill/till, terrestrial slag, and submerged slag were evaluated to investigate the major controls on inorganic mobility. The average inorganic

concentration reported for each of the seven SEP fractions (as listed above) was evaluated for each of these media. Element-specific fractionation is discussed below.

Figures 5.4.1-1 through 5.4.1-7 provide summaries of SEP fractionation by media for the select inorganic metals (i.e., arsenic, cadmium, chromium, copper, lead, mercury, and zinc). The y-axis on the graphs shows the contribution of the inorganic compound in each fraction in clay/alluvium, fill/till, terrestrial slag, or submerged slag to the total inorganic compound concentration (sum of SEP fractions), and the contribution of each fraction on a percentage basis to the total inorganic compound concentration.

Arsenic

Figure 5.4.1-1 is a summary of the SEP fractionation data for arsenic by concentration in each fraction and media (Figure 5.4.1-1a), and percent of each fraction per media (Figure 5.4.1-1b). The SEP data in Figure 5.4.1-1a show that the greatest concentration of arsenic was recovered from the submerged slag sample, and the lowest concentration of arsenic was recovered from the clay and alluvium sample. The dominant association of arsenic in the solid phase for all media is with the sulfide fraction (F6), suggesting precipitation with sulfide minerals is a mechanism of control for arsenic mobility. The observation that 13.7 to 32.5 percent of arsenic in all media was associated with the residual fraction (e.g., recalcitrant minerals) (F7) is noteworthy (Figure 5.4.1-1b). The extracting solution for the residual fraction of the SEP is more destructive than a total metals extraction. Consequently, inorganics present in this fraction have a very low potential to be mobilized under any number of geochemical conditions. Secondary to the mass of arsenic bound to the sulfide fraction is the mass of arsenic bound within the crystalline (F5) and amorphous (F4) fractions, suggesting that sorption of arsenic to metal oxides may provide an additional arsenic immobilization process.

The absence of arsenic in the exchangeable fraction (F1) suggests that there is not a large pool of arsenic that can be readily transported. The distribution of arsenic appears to be similar for all media tested (i.e., clay/alluvium, fill/till, terrestrial slag, and submerged slag). Though the total concentration of arsenic was highest for the submerged slag, the SEP distribution demonstrates that none of the arsenic is present in the two fractions that are generally considered bioaccessible and/or have a higher potential to be mobilized (exchangeable [F1] and carbonate [F2]). These data, along with the result showing the residual fraction of the submerged slag (F7) was 32.5 percent, suggest that arsenic remaining in the submerged slag is relatively immobile.

Arsenic concentrations may be high in the alluvium and slag, ranging from the IRSL to above the BTV and is above the SV in many samples. However, groundwater from alluvium below the slag shows arsenic below the MCL. This suggests the arsenic is bound to the aquifer matrix material, alluvium and/or slag, and is thus immobile. Based on soil and groundwater from co-located samples, although arsenic levels are high on a total basis, groundwater analyses indicate arsenic is apparently immobile. The groundwater results are below the MCL. For example, solid matrix sample MW-303H (108 to 109 ft bgs) had a reported arsenic concentration of 8.4 mg/kg. MW-303H, which is screened across the 108 to 109 ft bgs depth interval, had no reportable arsenic to a detection limit of 5µg/L.

Cadmium

Figure 5.4.1-2 is a summary of the SEP fractionation data for cadmium by concentration in each fraction and media (Figure 5.4.1-2a), and percent of each fraction per media (Figure 5.4.1-2b). The SEP data in Figure 5.4.1-2a show that the greatest concentration of cadmium was recovered from the clay and alluvium sample, and the lowest concentration of cadmium was recovered from the submerged slag sample.

For all media but the submerged slag, cadmium was present in the exchangeable fraction (F1) (Figure 5.4.1-2b). Cadmium present in the exchangeable fraction represents the mass with the greatest potential to be mobilized. Cadmium present in clay/alluvium is mostly associated with organic matter (F2, 59.7 percent). For the other media the organic (F2), carbonate (F3) and metal hydroxide fractions (F5) are important immobilization processes. The association of cadmium with these fractions suggests that complexation with organic matter, as well as sorption and/or precipitation are likely the dominant mechanisms controlling the mobility of cadmium. The organic fraction in the clay/alluvium appears to have more cadmium associated with it than the other media tested, and may be a result of a greater source of carbon for complexation. Similar to arsenic, cadmium in the submerged slag yielded higher proportions that became mobile only in the residual (F7, 12.9 percent) and sulfide (F6, 31.2 percent) fractions compared to other media. Based on the SEP results, cadmium is generally found in fractions with a limited potential to be mobilized. Higher percentages of cadmium in the residual and sulfide fractions, which strongly immobilize cadmium compared to other fractions, of the submerged slag compared to other media, indicate that the potential for cadmium to be mobilized is less in the submerged slag than in the other media tested.

Chromium

Figure 5.4.1-3 is a summary of the SEP fractionation data for chromium by concentration in each fraction and media (Figure 5.4.1-3a), and percent of each fraction per media (Figure 5.4.1-3b). The SEP data in Figure 5.4.1-3a show that the greatest concentration of chromium was recovered from the submerged slag sample, and the lowest concentration of chromium was recovered from the terrestrial slag. The dominant association of chromium in the solid phase for all media is with the residual fraction (F7), suggesting that the majority of soil chromium is tightly bound to the solid matrix with a limited potential to be remobilized. As noted above, the extracting solution for the residual fraction of the SEP is more destructive than a total metals extraction. Consequently, chromium present in this fraction has a very low potential to be mobilized under any number of geochemical conditions. Secondary to the mass of chromium bound to the residual fraction is the mass of chromium bound within the sulfide (F6) and organic (F3) fractions.

The absence of chromium in the exchangeable fraction (F1) suggests that there is not a large pool of chromium that can be readily transported. Furthermore, the association of chromium with more recalcitrant fractions strongly suggests that the overwhelming majority of chromium is trivalent (versus hexavalent). The distribution of chromium appears to be similar for all media tested (i.e., clay/alluvium, fill/till, terrestrial slag, and submerged slag) with organic fractions having a greater importance than other secondary fractions for clay and alluvium and fill/till. Though the total concentration of chromium was almost twice as high in the submerged slag compared to the other media tested, the SEP distribution demonstrates that greater than 90 percent of the chromium is present in the residual fraction. This fraction has an extremely low potential to be mobilized with changing geochemical conditions.

Copper

Figure 5.4.1-4 is a summary of the SEP fractionation data for copper by concentration in each fraction and media (Figure 5.4.1-4a), and percent of each fraction per media (Figure 5.4.1-4b). Similar to the SEP data for arsenic, the greatest concentration of copper was recovered from the submerged slag sample, and the lowest concentration of copper was recovered from the fill/till sample (Figure 5.4.1-4a).

The distribution of copper appears to vary by media (Figure 5.4.1-4b). The majority of copper in the clay/alluvium is associated with the carbonate (F3, 30.5 percent) and sulfide (F6, 24.5 percent) fractions. Copper is not as prevalent in the carbonate fraction for other media. The majority of copper in both the fill/till and terrestrial slag is present in non-crystalline (F4, 30.9 percent in fill/till and 27.7 percent in

terrestrial slag) and metal hydroxide (F5, 25.3 percent in fill/till and 20.5 percent in terrestrial slag) fractions indicating that sorption is likely the dominant immobilization process for copper in these media. Copper levels were highest in the submerged slag and contrary to the association of copper in the other media, over 80 percent of submerged slag was associated with the residual (F7, 41.0 percent) and sulfide (F6, 40.8 percent) fractions. These data like arsenic and cadmium suggest that copper in submerged slag has a lower potential to be mobilized than other media.

Lead

Figure 5.4.1-5 is a summary of the SEP fractionation data for lead by concentration in each fraction and media (Figure 5.4.1-5a), and percent of each fraction per media (Figure 5.4.1-5b). The greatest concentration of lead was recovered from the terrestrial slag sample, and the lowest concentration of lead was recovered from the submerged slag sample (Figure 5.4.1-5a).

Lead distribution, by fraction, appears to vary by media (Figure 5.4.1-5b) with the majority of clay/alluvium and submerged slag lead present in the residual fraction (F7, 52.4 percent). Lead in fill/till and terrestrial slag is predominantly associated with the metal hydroxide (F5, 69.8 percent) fraction with a small fraction of lead associated with carbonates (F3, 3.5 percent).

Mercury

Figure 5.4.1-6 is a summary of the SEP fractionation data for mercury by concentration in each fraction and media (Figure 5.4.1-6a), and percent of each fraction per media (Figure 5.4.1-6b). The greatest concentration of mercury was recovered from the terrestrial slag sample, and the lowest concentration of mercury was recovered from the submerged slag sample (Figure 5.4.1-6a).

In the clay/alluvium, fill/till, and terrestrial slag samples, the majority of mercury is associated with the organic matter fraction (F2), suggesting that mercury is complexing with organic material. Submerged slag mercury is predominantly associated with the metal hydroxide fraction (F5, 57.1 percent), with a smaller component associated with organic (F2, 29.2 percent) and sulfide (F6, 13.7 percent) fractions.

Zinc

Figure 5.4.1-7 is a summary of the SEP fractionation data for zinc by concentration in each fraction and media (Figure 5.4.1-7a), and percent of each fraction per media (Figure 5.4.1-7b). The greatest

concentration of zinc was recovered from the terrestrial slag sample, and the lowest concentration of zinc was recovered from the clay and alluvium sample (Figure 5.4.1-7a).

Zinc in the clay/alluvium, fill/till, and terrestrial slag is primarily associated with the carbonate (F3), non-crystalline (F4) and metal hydroxide (F5) fractions. The residual (F7, 55.6 percent) and sulfide (F6, 27.3 percent) fractions contain the majority of zinc in the submerged slag suggesting that, though concentrations are elevated, the vast majority of zinc in the submerged slag has a limited potential to be mobilized. Zinc was reported in the exchangeable fraction of all media submitted for SEP analyses ranging from 6.5 (submerged slag) to 340.3 mg/kg (clay and alluvium).

Inorganic Mobilization Evaluation

Table 5.4.1-3 provides a summary of the predominant metal immobilization processes and condition(s) that may result in mobilization of inorganics from these fractions. It should again be noted that zinc was present in the exchangeable fraction (F1) for all media. Cadmium was present in the exchangeable fraction for all media except in submerged slag. Inorganics in the exchangeable fraction are relatively mobile and have the potential to migrate. The remaining SEP fractions have been grouped by the major geochemical condition(s) that would be anticipated to increase mobility. As noted above, inorganics present in the residual fraction (F7) have a low potential to be mobilized and thus are not discussed further. Major mobilization processes are as follows:

Fractions subject to mobilization through mild acid dissolution – the carbonate fraction (F3) contains inorganics that have been immobilized through association with carbonate and or other soil minerals that are pH sensitive. A pH of approximately 5.2 standard units (S.U.) favors dissolution of carbonate minerals. As a consequence, inorganics associated with carbonates and/or unstable with slight pH decreases may mobilize inorganics.

Fractions subject to mobilization through reductive dissolution – the non-crystalline (F4) and metal hydroxide (F5) fractions contain inorganics that have been immobilized through association (sorption and/or precipitation) with common oxide and oxyhydroxide soil minerals (e.g., hematite, goethite). Under reducing conditions, dissolution of these minerals may release the previously immobilized inorganic. Generally, greater dissolution and subsequent inorganic mobilization is observed for non-crystalline (F4) than metal hydroxide (F5) fractions.

Fractions subject to mobilization through oxidative dissolution – the sulfide (F6) and organic (F2) fractions contain inorganics that may be mobilized through oxidation. Oxidation of organic matter may

result in release of previously complexed inorganics. Similarly, oxidative dissolution of sulfide minerals may also release previously precipitated or coprecipitated inorganics.

Because inorganics have varying geochemical behavior, any number of processes alone or in combination may affect the mobility and long-term transport. Concurrently, processes that may reduce the mobility of one inorganic may increase the mobility of a different inorganic. This complexity is apparent when reviewing the major binding phases for Site inorganics and geochemical processes that may affect inorganic mobility (Table 5.4.1-3). Arsenic, chromium, and mercury in all media have the most consistent distribution. The majority of arsenic is associated with sulfides in all media. The major process that could lead to mobilization of arsenic sulfides is oxidative dissolution. However, reductive dissolution may also mobilize arsenic bound in less predominant fractions like the non-crystalline (F4) and metal hydroxide (F5) fractions.

Rainwater coming in contact with Site soils or slag is anticipated to contain relatively high DO and a slightly acidic pH. The pH of surface water in the LVR is generally higher than that of rain water. The SPLP extraction, discussed in the following subsection, provides an estimate of the effects of inorganic leaching due to rainwater. Based on the SEP fractionation results, it is anticipated that inorganics present in the exchangeable fraction (F1) (i.e., cadmium and zinc) and carbonate fraction (F3) (i.e., cadmium, copper, lead, and zinc) would have the highest potential to be mobilized by infiltrating rainwater. The relatively high DO levels associated with rainwater may also mobilize some inorganics associated with poorly developed sulfide minerals in all media (sediments would be of potential highest concern).

Groundwater pH and ORP data from groundwater samples collected in the Plant and Slag Pile Areas during previous groundwater sampling events were reviewed to ascertain if there was a high potential to mobilize soil inorganics if groundwater should come in contact with soil. The groundwater pH in both the Plant and Slag Pile Areas was circum-neutral (low pH = 6.36, high pH = 7.03). The groundwater ORP appears to be neither reducing (low ORP = -94 mV) nor overly oxidized (high ORP = 28.4 mV). These data suggest that increased mobility of inorganic COIs in soil is not expected if groundwater came in contact with soil.

5.4.1.2 SPLP Results

Soil samples collected from the Plant Area soils, terrestrial slag, and sediment were collected and submitted for SPLP and inorganic analyses. These tests were performed to provide additional estimates of inorganic mobility. The SPLP was designed to characterize the mobility of a constituent as rainfall

migrates through a soil column. The extraction fluid is intended to simulate precipitation. East of the Mississippi River the fluid is slightly more acidic at pH 4.20 reflecting the acidity generated from heavy industrialization and coal utilization. SPLP results are discussed in the following subsections.

Plant Area SPLP Results

Table 5.4.1-4 is a summary of SPLP results for the inorganic COIs investigated in Site soils and terrestrial slag. The GWSVs for the Site, as utilized in [Section 4](#) of this report are included in Table 5.4.1-4 to investigate inorganics in specific media that, if mobilized, may result in groundwater concentrations above screening levels. For screening purposes, MCLs or Tap Water RSLs SVs were utilized. It should be noted that this comparison does not account for any mixing that may occur when this water reaches groundwater or surface water. Inorganics in soil and terrestrial slag SPLP extracts greater than the SVs in one or more samples include: cadmium, manganese, zinc, and lead (a single terrestrial slag sample).

The higher leachability of zinc and cadmium (by comparison to SVs and overall leachability compared to other metals) is consistent with the results from the SEP analyses that indicated that a fraction of both cadmium and zinc are present in exchangeable fraction (F1) (Table 5.4.1-4). Manganese and cobalt were not evaluated using the SEP. Clay samples were above SVs more frequently than other media. Cadmium and lead were detected above SVs in two separate terrestrial slag samples. The low concentrations of leachable chromium reported in SPLP extracts supports earlier observations from soil and groundwater sampling and analyses, and SEP results, which strongly support a trivalent speciation of chromium.

To evaluate the overall leachability of inorganic COIs, the soluble mass was converted to mg/kg and compared to the total mass (Table 5.4.1-5). Overall, the leachability of inorganic COIs is lower in the terrestrial slag compared to Site soils (clay and alluvium). All concentrations of inorganic COIs in terrestrial slag had a soluble mass (as defined by SPLP) less than one percent. Concentrations of manganese, zinc, cobalt, and cadmium were greater than one percent soluble mass in soil samples.

Appendix G-5-1 provides scatter-plot comparisons of inorganic COI mass versus total mass for terrestrial slag and soil samples collected at the Site. Generally, these data plot along a line that rises from the bottom left corner of the graph to the upper right corner demonstrating a trend or correlation in increased inorganic mobility (x-axis) as the total concentration (y-axis) increase. From these data, a threshold concentration may be established that is protective of groundwater. The data in Appendix G-5-1 show that this trend is only weakly observed for select inorganics. These data are summarized as follows:

- Arsenic - Soluble and total concentrations in soil show no correlation. Arsenic concentrations in terrestrial slag, though higher than soil, show an inverse trend (arsenic appears to be more mobile at lower concentrations). At the low SPLP values reported (all values within 1 ppb), this correlation for the terrestrial slag may not be representative. These results suggest that: 1) arsenic is present in higher concentrations in the slag; and 2) arsenic in the slag is in a less leachable form.
- Cadmium - Soluble and total concentrations in soil show no correlation. A potential correlation is apparent in the terrestrial slag, though as noted for arsenic, SPLP results are relatively low.
- Cobalt – There are no clear correlations for soil or terrestrial slag.
- Chromium – There are no clear correlations for soil or terrestrial slag.
- Copper – There are no clear correlations for soil or terrestrial slag.
- Iron – No clear correlation for either media.
- Lead – Potential correlation for soil. No correlation for terrestrial slag.
- Manganese – There are no clear correlations for soil. There is a positive correlation (increased soluble mass with increase in total mass) in terrestrial slag.
- Mercury – There are potential correlations in both soil and terrestrial slag. However, soluble concentrations from SPLP extract and total (soil) mercury levels are extremely low suggesting that these correlations may not be representative.

The SPLP data collected to date have demonstrated that Site soils and terrestrial slag have limited potential to leach inorganic COIs. The SPLP data collected to date have also demonstrated that though inorganic COIs may be present at elevated concentrations in soil and terrestrial slag, there are no clearly defined and consistent trends (at meaningful soluble inorganic levels) that demonstrate increased inorganic mobile mass with increasing total inorganic mass.

Total concentrations of arsenic, chromium, copper, iron, lead, manganese, and zinc are substantially higher (in some cases order of magnitude higher) in the terrestrial slag than the soil. Nonetheless, a review of the scatter-plots (Appendix G-5-1) shows that soluble concentrations for these inorganics falls within the range (or near to the range) reported for soils.

Sediment SPLP Results

Duplicate sediment samples were collected from two sampling locations at the LVR for SPLP extraction and inorganic analyses. One replicate sample consisted of a routine sample that contained sediment and submerged slag. The second sample at each location consisted of a sample that was sieved to segregate

the submerged slag from river sediment. The submerged slag sample was also submitted for SPLP extraction and analyses. SPLP results are summarized in Table 5.4.1-6 with applicable surface water criteria. The SPLP inorganic extraction results provide conflicting results. For the sample collected at location LRS-413, the absence of inorganics in the submerged slag only sample suggests that these inorganics have a limited mobility. Analysis of the submerged slag and sediment sample from the same location showed elevated arsenic and lead levels (estimated) that would suggest that the majority of these and other inorganics were associated with sediment and not the submerged slag. The SPLP results from location LRS412 showed a different distribution with higher leachable concentrations reported for most inorganics in the submerged slag. These data provide conflicting information on the fate and transport of inorganic COIs in submerged slag and sediments. The small number of samples with which to reach these conclusions makes drawing conclusions regarding the fate and transport of the COIS in the submerged slag difficult.

5.4.1.3 Specialized Leachability Testing – Terrestrial and Submerged Slag Materials

During field sampling efforts in 2009, samples from upland areas where terrestrial slag was present and submerged slag from the LVR were collected to further evaluate the leachability of inorganic COIs. A specialized leachability procedure was used to estimate the mobility of inorganic COIs in terrestrial and submerged slag. The specialized leachability procedure is similar to the SPLP with the following differences:

- Material in the specialized leachability procedure is tumbled whereas the SPLP procedure requires crushing of the sample
- The specialized leachability procedure evaluated the leachability of inorganics at a pH of 4.2 (like the SPLP), but also evaluated the effect of LVR Water pH (8.5)
- Samples of filtered and unfiltered materials were analyzed
- Samples were analyzed in triplicate for the specialized leachability procedure

Table 5.4.1-7 provides a summary of specialized leachability testing results. The extractant column in the table shows the pH of the extracting solution (LVR Water = pH 8.5 and SPLP = pH 4.2). Appendix G-5-2 provides graphs that compare the average concentration of filtered and unfiltered, pH 8.5 and pH 4.2, terrestrial and submerged, slag inorganic COIs leachability results. For all inorganic COIs, the leachable metals were substantially higher in the unfiltered terrestrial slag compared to the unfiltered submerged slag. With regard to the pH differences in the leaching fluids, the results for the leaching tests were inconclusive

5.4.1.4 TCLP Results

TCLP and inorganic analyses were performed on select samples collected from the Plant and Slag Pile Areas. The extracted fraction of an inorganic from the TCLP is operationally defined as the fraction that could potentially be mobilized within a landfill. For fate and transport analyses provided herein, these data were reviewed, like SPLP, to provide semi-quantitative information on general inorganic mobility.

Plant Area TCLP Results

Table 5.4.1-8 is a summary of TCLP results for soil inorganic COIs in the Plant Area. Cadmium was detected above the TCLP standard in a single sample. The TCLP extractable cadmium concentration in soils varied from less than 0.004 mg/L to 1.2 mg/L, with an average cadmium concentration of 0.3 mg/L. No other constituents were detected above TCLP standard. The relatively low concentrations of inorganic COIs in TCLP extracts provides additional evidence that inorganic COIs have limited migration potential within the Plant Area.

Slag Pile TCLP Results

Table 5.4.1-9 is a summary of TCLP results for soil organic COIs within the Slag Pile. Cadmium (one sample) and lead (three samples) were detected above the TCLP standards. Other inorganic COIs had low reported TCLP extractant concentrations. Like the soil in the Plant Area, TCLP extractable cadmium levels varied. TCLP extractable cadmium levels ranged from 0.008 mg/L to 1.1 mg/L with an average cadmium concentration of 0.25 mg/L. The TCLP extractable lead concentration ranged from less than 0.01 mg/L to 7.2 mg/L with an average concentration of 2.29 mg/L. Though the use of these data to provide insights to inorganic mobility is limited, they do demonstrate the variability of inorganic mobility within the Slag Pile.

Sediment TCLP Results

Sediment TCLP results from sampling of on-site ponds and the LVR in 1992 and 1994 are presented in Table 5.4.1-10. All inorganic COIs were detected at concentrations below potentially applicable TCLP leachability standards in these samples.

5.4.2 Potential Migration of Contaminants in Groundwater

The COIs that were detected in groundwater samples from OU1 at concentrations above SVs were the following (Table 4.3.1-1):

- Aluminum (total only)
- Arsenic (total and dissolved)
- Barium (total only)
- Beryllium (total only)
- Cadmium (total and dissolved)
- Chromium (total only)
- Cobalt (total and dissolved)
- Copper (total only)
- Iron (total and dissolved)
- Lead (total and dissolved)
- Manganese (total and dissolved)
- Mercury (total only)
- Nickel (total only)
- Vanadium (total only)
- Zinc (total and dissolved)
- 1, 2-dichloroethane
- VC
- Bis(2-ethylhexyl)phthalate

Many factors influence the rate of COI movement in an aquifer system. These include the physiochemical properties of the COIs (e.g., solubility, density, viscosity, etc.), and the physiochemical properties of the environment (e.g., soil permeability, porosity, bulk density, particle size distribution, groundwater and soil/sediment geochemical conditions, soil mineralogy, speciation, extent and connectivity of fractures, etc.). Because all these factors can affect the rate of COI movement through aquifers, it is very difficult to predict such movement.

The presence of certain of these COIs in the dissolved fraction of the groundwater at OU1, and the hydraulic conductivity of the soils at OU1 confirm the ability of those COIs in the dissolved phase of the groundwater to migrate. The existing groundwater gradients (flow direction potential toward the LVR) and subsequent nearby discharge points constrain the migration and potential exposure to COIs in groundwater.

The hydraulic conductivity in WBZ1 and the relatively steep gradients toward the LVR suggest the contamination present in WBZ1 will migrate horizontally fairly readily within this zone. Additionally, the generally lower hydraulic conductivity of WBZ2 relative to WBZ1 and locally the upward gradient from WBZ2 toward WBZ1 will constrain contamination moving into WBZ2. Particular remedial actions could cause changes in the gradients, direction of flow or discharge points, and such changes should be considered in remedial action evaluation and selection.

5.4.3 Potential Migration of Contaminants in Air

Limited air sampling was performed during the RI at OU1. Air samples were collected during a portion of the test pit exploration to investigate the limits of the Slag Pile ([Section 4.1.7](#)). These data did not document the presence of any COIs in excess of screening criteria limits. Additionally, the majority of

the COIs investigated at OU1 are not volatile. The potentially volatile COIs are mercury, VOCs, and SVOCs. The lack of detection of mercury in the limited air testing suggests that mercury is present in its non-volatile, mineral form rather than as elemental mercury. As to VOCs and SVOCs, when found in soils or groundwater above SVs, they were either in sufficiently low concentrations, were strongly bound to the soil particles or were present in subsurface soils (> 2 ft bgs) or in groundwater more than 2 ft bgs, so that the resulting potential for volatilization was low. No other COIs detected in excess of screening criteria in soil, surface runoff, or surface water samples are likely to volatilize to the atmosphere.

5.4.4 Potential Migration of Contaminants in Surface Water and Surface Water Runoff

Surface runoff water can erode soil (or slag) particles and transport these in overland flow for deposition at a lower elevation or deliver sediment to receiving waters, such as the LVR. Surface runoff water can also pick up dissolved compounds from contaminated soils and deliver impacted water to receiving waters as a nonpoint source of pollution. Another potential mechanism of COI migration in surface water is via diffusion. However, diffusion is rarely a dominant transport mechanism unless the water is stagnant.

The COIs that were detected in surface water samples from OU1 at concentrations above SVs were the following (Table 4.3.1-1):

- Aluminum (total only)
- Cadmium (total and dissolved)
- Chromium (total only)
- Copper (total and dissolved)
- Iron (total only)
- Lead (total and dissolved)
- Nickel (total and dissolved)
- Selenium (total and dissolved)
- Silver (total and dissolved)
- Zinc (total and dissolved)
- Cyanide (total only)

All of these compounds may be transported in surface water since they are likely associated with particulate matter in soil and/or sediments. The COIs may remain sorbed to particulate matter that is subsequently transported, desorb in the water column, or resorb to bottom, or be carried as suspended sediments. The fate and transport of the inorganic COIs are dependent upon the degree to which the materials can be carried in suspension, which is size dependent, and on physiochemical conditions, which influence the dominant chemical species.

Slag from the Slag Pile located adjacent to the LVR has the potential to erode into the river and be transported downstream. The slag observed within the river varies considerably in size from sand and

gravel to small slag pebbles to large boulders several ft in diameter. Once slag has eroded into the river, the distance the slag travels downstream from the point of entry is influenced by many factors, including particle size and river velocity. Larger slag boulders are anticipated to be located closer to the Site than fine-grained sediment. Smaller particles can be more easily transported downstream. Slag is evident in sediment present at the mouth of the LVR when it discharges into the Illinois River.

5.4.5 Potential Migration of Contaminants in Sediments

Chemicals from contaminated surface water and/or sediments may be remobilized or transported by surface runoff or surface water, producing contaminated surface water and/or sediments. There is also potential for infiltration of surface water through contaminated sediments to produce contaminated groundwater. The COIs from OU1 that were detected in sediment samples at concentrations above SVs were the following (Table 4.3.1-1):

- Arsenic
- Cadmium
- Chromium
- Cobalt
- Copper
- Lead
- Mercury
- Nickel
- Silver
- Zinc
- Cyanide
- Acenaphthene
- Acenaphthylene
- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(k)fluoranthene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Bis(2-ethylhexyl)phthalate
- Carbazole
- Chrysene
- Dibenzo(a,h)anthracene
- Fluoranthene
- Indeno(1,2,3-cd)pyrene
- Phenanthrene
- Pyrene
- Aroclor 1242
- Aroclor 1254
- Aroclor 1260
- 4,4'-DDD
- 4,4'-DDT
- Alpha-chlordane
- Dieldrin
- Endrin
- Endrin aldehyde
- Gamma-chlordane

All of these compounds may be transported with sediments since they are associated with impacted sediments. The COIs may remain sorbed to particulate matter that is subsequently transported, desorb in the water column, volatilize, resorb to bottom or suspended sediments, or leach to the groundwater. SVOCs and PCBs will tend to remain sorbed to particulate matter that is subsequently transported. The fate and transport of the inorganic COIs is dependent upon physiochemical conditions, which influence the dominant chemical species.

The mobility of the aforementioned COIs in sediments to groundwater is dependent upon sediment chemistry conditions (e.g., pH, redox, presence of dissolved organic matter or metal oxides). Soluble forms of all the aforementioned COIs are mobile, but other forms may adsorb to sediments. The redox conditions in the sediments may also have an important role in dictating the mobility of most of the inorganic compounds listed above. Since most inorganic COIs that were observed in sediment samples in excess of screening criteria were also observed in groundwater samples in excess of screening criteria (the exception is antimony), it is possible that these COIs have mobilized to the groundwater from sediments.

5.5 POTENTIAL CONTAMINANT MIGRATION ROUTES FOR OU2

The following sections discuss the potential migration of contaminants in soils/solids, groundwater, air, surface water and surface water runoff at OU2.

5.5.1 Potential Migration of Contaminants in Soils/Solids

For the purposes of discussion for OU2, the term “soil/solid” includes the solid matrix material comprising the unconsolidated surface deposits. These materials consist of natural soils and glacial deposits, some of which have been reworked; slag, sinter and other by-products of the zinc smelting operations; and some fraction comprised of brick, ceramic, and other building debris co-mingled of along with the sinter and slag materials. The aboveground building material and debris pile material also are discussed as “soils/solids.” Table 4.3.2-1 summarizes the contaminants detected in soil/solid samples collected from OU2 at concentrations exceeding the RSLs in more than one sample per medium. Of these contaminants, the HHRA and ERA (Appendix RA), summarized in [Sections 7.0](#) and [8.0](#) of the RI report, investigate potential or actual risk to human health and the environment.

Contaminants present in soils/solids may tend to adsorb to soil particulates and organic matter and may be transported by several processes, including physical transport by surface water runoff (including transport into subsurface drainageways such as old sewers), physical transport by dust migration, volatilization, and

leaching into deeper subsurface soil. A likely migration route for these contaminants is from soil to groundwater, which is further discussed below. In addition, erosion and transport in surface water are discussed in [Section 5.5.4](#). Other than fugitive dust generation, migration of these contaminants to air through volatilization is not significant because the contaminants most frequently detected at concentrations exceeding the RSLs are inorganic contaminants that are not volatile (except for mercury). [Sections 5.5.1.1](#) through [5.5.1.3](#) discuss the potential migration of metals; VOCs; and SVOCs, pesticides, and PCBs, respectively, in soil.

5.5.1.1 Metals

The mobility of metal contaminants in soil depends on soil chemistry conditions (such as pH, redox, and presence of organic matter or metal oxides). Soluble forms of metal contaminants are relatively mobile, but other forms may adsorb to sediment or soil. The redox conditions in soil may also have an important role in dictating the mobility of most inorganic contaminants. Because all of the metal contaminants detected in the soil/solid samples also were detected in groundwater samples (at concentrations exceeding GWSVs), it is likely that these contaminants have mobilized to groundwater.

Metals speciation affects the fate and transport of metals in soil. However, no metals speciation testing was conducted during the RI. Different species of the same metal behave differently and have varied risk. For example, chromium typically exists in the hexavalent and trivalent forms. For the purposes of the risk evaluation (Appendix RA), it was assumed that trivalent and hexavalent species concentrations exist in a 1:6 ratio. This ratio is a conservative estimate that weights the toxicity of each species when speciation data do not exist. The speciation of chromium for risk assessment purposes is discussed further in the HHRA in Appendix RA.

The soil pH also affects the mobility of metals migrating from soil to groundwater with infiltrating precipitation or runoff. Soil pH at OU2 was evaluated using three methods: (1) *in situ* field measurements in July 2007, (2) laboratory analysis of soil samples collected during RI sampling events in July 2007 and October 2008, and (3) the NRCS Web Soil Survey. First, in July 2007, 18 surface soil samples were collected from 0 to 6 inches bgs in former main industrial area of OU2 and the soil pH was tested *in situ* (using direct soil measurement) using a Hanna HI 99121 kit for pH measurement. Second, during the July 2007 and October 2008 RI sampling events, the pH was measured for the initial sample extraction for each soil sample sent to an off-site laboratory for analytical SVOC, PCB, or pesticide analysis. During the two RI sampling events, surface soil samples from 124 locations were collected from across OU2 and analyzed by an off-site laboratory. Under the third method, the NRCS Web Soil Survey

database was used to obtain published information regarding the soil pH in LaSalle, Illinois (USDA 2010). The table below summarizes the minimum, maximum, average, and median soil pH values obtained using the three methods discussed above.

Method	Minimum pH (SU)	Maximum pH (SU)	Average pH (SU)	Median pH (SU)
July 2007 <i>in situ</i> field measurement	2.0	6.5	5.0	5.2
July 2007 laboratory analysis	1.0	8.8	6.3	6.7
October 2008 laboratory analysis	4.6	10.7	8.5	8.7
NRCS Web Soil Survey database	5.6	7.7	6.2 (weighted based on area)	--

Notes:

NRCS National Resource Conservation Service
SU Standard unit

The July 2007 *in situ* field measurements were performed in the former main industrial portion of OU2 and were analyzed using a different methodology than soil samples with pH results measured by the laboratory. Meanwhile, in July 2007, RI samples were collected from across all of OU2, and in October 2008, RI samples primarily were collected from the North Area/Northeast Periphery Area to expand the investigation boundaries. The pH values near in the vicinity of the former main industrial area of OU2 are slightly more acidic than the average OU2-area-wide and NRCS LaSalle pH values.

The metal contaminants, which are discussed in [Section 5.3.1](#), are generally more mobile under acidic conditions. Therefore, metals at concentrations exceeding the RSLs in soil potentially are more likely to impact groundwater when the soil pH is acidic. To further evaluate the potential for metals to migrate from soil to groundwater, a “multiple lines of evidence” approach was used. This approach consisted of: 1) a direct comparison of contaminant concentrations in soil to US EPA soil-to-groundwater screening criteria; 2) use of TCLP and SPLP test results to assess the leachability of contaminants under varying conditions; and 3) a direct comparison of SPLP soil sample results to groundwater sample analytical results to evaluate whether the same contaminants present in soil are present in groundwater. A discussion of each evaluation is presented below.

Soil-to-Groundwater Comparison

The US EPA has put forth a listing of contaminant concentrations for soil that may impact groundwater, which are known as the “soil-to-groundwater” screening criteria. The soil-to-groundwater scenario was developed to investigate contaminant concentrations in soil that could contaminate groundwater at concentrations exceeding risk-based MCLs. Migration of contaminants from soil to groundwater can be

envisioned as a two-stage process: 1) release of contaminants from soil to soil leachate; and 2) transport of contaminants through the underlying soil and aquifer to a receptor well. The soil-to-groundwater scenario considers both of these fate and transport mechanisms. First, the acceptable groundwater concentration is multiplied by a dilution factor to obtain a target leachate concentration. For example, if the dilution factor is 10 and the MCL for a particular contaminant in groundwater is 0.05 mg/L, the corresponding target soil leachate concentration is 0.5 mg/L. The partition equation is then used to calculate the total soil concentration corresponding to this soil leachate concentration. This methodology was designed for use during the early stages of Site evaluation when information about subsurface conditions may be limited. Because of this constraint, the methodology is based on conservative, simplifying assumptions about the release and transport of contaminants in the subsurface (US EPA 2010b). The US EPA soil-to-groundwater screening criteria are split into two sets of SSLs, risk-based SSLs, which are protective of risk-based groundwater concentrations, and MCL-based SSLs, which are protective of MCL groundwater concentrations. The IEPA has similar soil-to-groundwater criteria in its “Proposed Amendments to Tiered Approach to Corrective Action Objectives” (TACO) (IEPA 2008b). The TACO soil-to-groundwater number comes from the minimum value for the soil component of the groundwater ingestion exposure route for Class I groundwater. The risk-based SSLs and the MCL-based SSLs are presented in Attachment 4 to the Consensus Document (Geosyntec and SulTRAC 2008). In addition, Attachment 4 – Revision 2 to the Consensus Document includes site-specific soil-to-GWSVs, which are the lowest of the risk-based SSL, MCL-based SSL, or TACO soil value. The site-specific soil-to-GWSV is referred to hereafter as the “basis value.” Soil-to-GWSVs exist for other analyte groups as well, including SVOCs, VOCs, PCBs, and pesticides. However, metals are the primary contaminants detected at concentrations exceeding the RSLs for the OU2 soil/solid samples. Therefore, metals are the focus of the soil-to-groundwater comparison analysis.

Table 5.5.1-1 presents the basis values for metals in soil compared to the soil boring metals results for OU2. This comparison represents a highly conservative approach. The basis values were exceeded at the vast majority of the soil boring locations. The soil-to-groundwater comparison therefore is not useful for assessing the extent of soil contamination that may be impacting groundwater at OU2 because results for all soil borings exceeded the basis values for one or more contaminants.

The soil-to-groundwater comparison results are highly conservative and indicate that groundwater could be heavily impacted by soil contamination. As a result of the soil-to-groundwater comparison indicating that groundwater could potentially be impacted from soil contamination, SPLP samples were collected from soil borings at OU2 to further evaluate soil-to-groundwater migration. The SPLP samples were

collected from soil boring sampling locations that are in the vicinity of MWs, which have actual groundwater data. Therefore, the SPLP and groundwater results are a better indicator of subsurface aqueous contaminant concentrations than solely relying on the soil-to-groundwater comparison results and will be used to evaluate both the nature and extent of contamination as well as possible risks to human health and the environment. Results for the soil samples collected from the borings for SPLP analysis were compared to the soil-to-groundwater basis values as discussed below.

Comparison of SPLP Test Results to Assess Leachability

Percolating rainwater may transport inorganic analytes into groundwater as indicated by the presence of metals in groundwater samples. Select soil samples from the Phase II soil investigation were analyzed for TCLP and SPLP metals (see [Section 4.2.2](#), Tables 4.2.2-8a and 4.2.2-8b for additional information). The TCLP analysis simulates landfill conditions by simulating the percolation of water and other liquids through solid waste in landfills. In the laboratory, the TCLP test is conducted using a leaching solution with a pH of 4.93 SUs. The TCLP analysis was conducted for disposal purposes only and is not discussed further in this section. The SPLP analysis leaches contaminants out of the soil matrix using an acid extraction solution that represents the process of rainwater traveling through soil media. The pH of the acid extraction solution used is 4.2 SUs. In [Section 4.2.2](#), SPLP metals results were compared to both the 40 CFR §261.24 regulatory levels as well as the US EPA groundwater MCLs. If a groundwater MCL did not exist for a particular analyte, then the US EPA Tap Water RSL was used. The SPLP soil results exceeded the GWSVs for antimony, cadmium, lead, and zinc, indicating that these metals may leach from soil to groundwater at concentrations exceeding the GWSVs. Table 4.2.2-8b lists the soil sampling locations from which samples were collected for SPLP analysis and the SPLP results compared to the GWSVs.

Results for the soil boring sampling locations from which samples were collected for SPLP analysis were compared to the soil-to-groundwater comparison results for soil samples from the same sampling locations. Table 5.5.1-2 summarizes locations where the soil sample results exceeded the basis values and where the SPLP sample results exceeded the GWSVs. In Table 5.5.1-2, soil boring locations where both values were exceeded at the same sampling location and depth are highlighted in red, and contaminants whose results exceeded both the basis value and the GWSV are listed in the column titled "Contaminants with results exceeding both values." Results for 12 of the 22 SPLP samples exceeded both the basis value and GWSV for the same contaminant(s). Eight of the SPLP samples whose results exceeded both values were surface samples (from 0 to 2 ft bgs), and the remaining four samples were

collected from the subsurface (ranging from 6 to 12 ft bgs). The results for cadmium exceeded both the basis value and GWSV most frequently, with 10 exceedances of both criteria.

Direct Comparison of SPLP Soil Sample Results to Groundwater Sample Analytical Results

To further assess whether contaminants in soil are impacting groundwater, the SPLP soil results that exceeded the GWSVs were compared to the groundwater sample analytical results. Figures 5.5.1-1 and 5.5.1-2 show the surface and subsurface SPLP soil sample results, respectively, compared to the groundwater sample total metals results for the September 2008 groundwater sampling event. SPLP soil sample results were compared to results for groundwater samples collected from the nearest MW (within 112 to 250 ft of the SPLP soil boring location). Because groundwater results are from wells that are located up to a couple hundred feet away from soil borings with SPLP results, it is possible that soil impacts closer to the wells could affect groundwater results at those locations; therefore, this comparison should be used as an approximation when evaluating soil to groundwater impacts. Figures 5.5.1-1 and 5.5.1-2 show only contaminants whose results exceeded both the basis values and the GWSVs as listed in Table 5.5.1-2. The SPLP surface and subsurface sample results are not consistently higher or lower higher than the groundwater sample results. Antimony tended to have the most similar soil SPLP and groundwater results. Cadmium results for groundwater tended to be the most variable between neighboring MW locations, which made comparison of the groundwater and SPLP results impractical. The fate and transport of contaminants in groundwater is further discussed in [Section 5.5.2](#).

Samples analyzed using the SPLP method do not yield a perfect representation of field conditions and may be conservative in some aspects and less conservative in others. The SPLP method uses a lower pH than that of ambient groundwater in the OU2 area, and the analytical method uses a shaker device to combine the soil sample and acid extraction solution. The shaker device runs for 18 hours at 30 repetitions per minutes and is intended to mimic the interaction between fluid and soil. However, the device can mobilize more metals than the relatively slow, natural processes of percolation and subsurface flow. These aspects indicate that the SPLP approach probably is conservative because it yields results that exceed the actual groundwater concentrations. An aspect of the SPLP method that may underestimate metals mobility is its high liquid-to-solid ratio of 20:1, which is significantly higher than actual subsurface conditions at OU2. The high ratio results in a lower leachate concentration because of sample dilution. Therefore, the metals concentrations in the SPLP extract solutions likely differ from actual metals concentrations in groundwater.

Summary of Potential Migration of Metals in Soils/Solids

As discussed throughout [Sections 4.2.2](#) through [4.2.4](#), metals are present throughout OU2 in all soil/solid media that have been sampled. The acidic soil at OU2, especially the main industrial portion of OU2, may facilitate the contaminant migration from soil to groundwater. In addition, multiple lines of evidence regarding metals leaching from soil to groundwater indicate that a possible source of metal contamination in groundwater is overburden soil and solid material.

5.5.1.2 VOCs

PCE and TCE are the only VOCs that are chemicals of potential concern in soils/solids at OU2. PCE and TCE concentrations exceeded the US EPA RSLs at one soil boring location at a depth of 4 to 6 ft bgs. Losses from volatilization are typical mechanisms of transport for these contaminants. However, PCE and TCE apparently are transported through subsurface soil by percolating rainwater as indicated by the presence of both of these contaminants in nearby groundwater wells.

Binding and sorption of chemicals to subsurface soils are controlled by soil density, soil porosity, the adsorption coefficient for organic carbon (K_{OC}), and the TOC content of the soil. The K_{OC} is a chemical-specific property, and select values are discussed in [Section 5.3](#). The TOC, soil density, and soil porosity properties can be measured. Soil density was not measured during the RI. The NRCS Web Soil Survey estimates the bulk density of soil at OU2 to be approximately 1.7 to 1.8 grams per cubic centimeter (g/cc) (USDA 2010).

The TOC content of soil can impact the mobility of organic contaminants such as PCE and TCE, thereby impacting the mobility of these organic compounds from soil to groundwater. Although most VOCs have low sorption potential compared to other chemicals, a high soil TOC content may retard downward movement. Organic matter can be used as a rough approximation for TOC content. The TOC content and organic matter in soil at OU2 was not analyzed as part of this RI. However, the NRCS Web Soil Survey presents the average value for organic matter at OU2 as approximately 0.66 percent (USDA 2010). Traditionally, for soils, a conversion factor of 1.724 has been used to convert organic matter to TOC content based on the assumption that organic matter contains 58 percent organic carbon. However, there is no universal conversion factor because the factor varies from soil to soil and from soil horizon to soil horizon within the same soil, and varies depending on the type of organic matter present in the sample. Conversion factors range from 1.724 to as high as 2.5 (Schumacher 2002). Using the conversion

factor of 1.724, the NRCS Web Soil Survey organic matter estimate yields a TOC content of 0.38 percent in soil at OU2.

As bulk density increases, pore space decreases and the amount of air and water held in soil also decreases. The estimated bulk density of 1.7 to 1.8 g/cc and the low organic matter of 0.66 percent for OU2 soil indicate compact soil with little pore space. Therefore, soil also will have low to moderate permeability as discussed in [Section 3.3.3.1](#). The presence of fill material across much of OU2 could potentially increase the permeability in localized areas of fill because of the poor compaction of fill materials in the subsurface. PCE and TCE have been detected in groundwater samples from multiple wells near the Rolling Mill, but the low to moderate soil permeability suggests that these VOCs may not be highly mobile through soil and groundwater. [Section 5.5.2](#) presents an additional discussion of the mobility of VOCs in groundwater.

5.5.1.3 SVOCs, PCBs, and Pesticides

SVOCs, PCBs, and pesticides tend to have limited mobility in the subsurface because of their tendency to sorb to soils. PAHs and PCBs have a high sorption potential. Therefore, they are expected to sorb to a significant extent to soil at OU2. The properties of pesticides are more variable, although as a group, pesticides tend to be large compounds with low solubilities and high sorption potentials.

PAHs were detected in soil, building material, and pile samples collected from across OU2 at concentrations exceeding the US EPA RSLs. PAH concentrations in surface soil samples exceeded the US EPA RSLs throughout the former main industrial area, along the eastern edge of Building 100, and along the northwest corner of Rolling Mill (Figure 4.2.2-9c). To a lesser extent than for surface soil, PAH concentrations in subsurface soil samples exceeded the US EPA RSLs in small pockets within OU2 (Figure 4.2.2-9d). In addition, PAH concentrations exceeded the US EPA RSLs in building material and pile samples collected from across OU2, but no central area of exceedances exists for the building material and pile samples (see Figures 4.2.3-8 and 4.2.4-8, respectively). The localized areas of PAH exceedances (such as in subsurface soil, building material, and pile samples) imply the limited mobility of PAHs within these matrices. Larger PAHs that have four or more rings (such as benzo[a]pyrene and chrysene) are expected to sorb more strongly to soils than PAHs with two rings (such as naphthalene). The smaller PAHs tend to be more mobile. Rainwater percolating through soil could leach out PAHs with two rings and transport them to groundwater. Naphthalene is one of the most mobile PAHs in soil and was detected in OU2 soil and groundwater samples, indicating that it is present in both the sorbed particulate phase and the soluble dissolved phase.

PCB concentrations in OU2 soil samples exceeded the US EPA RSLs in a localized area near Building 100. PCBs in the environment are insoluble, stable, persistent, and lipophilic. PCB congeners with higher chlorine contents and higher Aroclor numbers have higher hydrophobicity and binding affinity. PCBs strongly sorb to soils and sediments. Dissolution to the water column has also been shown to occur when organic solvents are present. The PCBs in soil at OU2 likely were released during former operations at Building 100. The limited detection of PCBs in groundwater indicates that PCBs are not significantly mobilizing from soil to groundwater.

Pesticide compounds were detected only in OU2 surface soil and pile samples collected from near the furnaces on the southern edge of OU2. Pesticides likely were applied during former manufacturing operations to keep roadways and railroad tracks clear of unwanted plants and weeds. The pesticides detected in the soil and pile samples include dieldrin and heptachlor. Both compounds tend to sorb to particulate and organic matter, and both have low mobility. The limited detection of pesticides in groundwater indicates that the compounds are not highly mobile from soil to groundwater.

5.5.2 Potential Migration of Contaminants in Groundwater

Table 4.3.2-1 summarizes the contaminants detected in OU2 groundwater samples at concentrations exceeding the GWSVs (groundwater samples analyzed for metals were field-filtered after the September 2008 sampling event). Of these contaminants, the HHRA and ERA (Appendix RA) and [Sections 7.0 and 8.0](#) of this RI report investigate the ones evaluated to pose a potential or actual risk to human health or the environment. The migration of contaminants detected in the OU2 groundwater samples at concentrations exceeding the US EPA Tap Water RSLs or MCLs is discussed below.

Many factors influence the rate of contaminant movement in an aquifer system, including the physiochemical properties of the contaminants (such as solubility, density, viscosity, etc.) and the physiochemical properties of the environment (such as soil permeability, porosity, bulk density, particle size distribution, groundwater and soil/sediment geochemical conditions, soil mineralogy, speciation, extent and connectivity of fractures, etc.). Because all these factors can affect the rate of contaminant movement through aquifers, it can be very difficult to predict such movement.

As previously described in [Section 3.0](#), groundwater is present in two water-bearing zones. Potentiometric surface drawings (Figures 3.3.3-1 and 3.3.3-3) show that WBZ1 is flowing towards the LVR. Vertical movement of groundwater from WBZ1 to WBZ2 (in addition to horizontal flow) is likely to influence contaminant migration from WBZ1 to WBZ2. The WBZ2 aquifer consists of fractured shale and is

continuous, especially in the eastern portion of OU2. As a result, horizontal flow in WBZ2 influences contaminant migration within this water-bearing zone. The hydraulic conductivity of WBZ1 and WBZ2 was established using slug tests at a series of OU2 wells in November 2009 (see [Section 3.3.3.1](#) for additional information regarding the slug tests). Table 3.3.3-3 lists the hydraulic conductivities derived from the slug tests. The hydraulic conductivities in OU2 ranged from 1.43×10^{-2} to 2.16×10^{-4} cm/s in WBZ1 and from 7.90×10^{-4} to 2.20×10^{-6} cm/s in WBZ2. Both sets of hydraulic conductivity values fall within the typical range for sandy silts and silty clays. As shown on Figures 3.3.3-2 and 3.3.3-4, groundwater in WBZ2 flows east toward the LVR. The potential migration of metals; VOCs; and SVOCs, pesticides, and PCBs respectively, in OU2 groundwater are discussed below.

5.5.2.1 Metals

Metals are the primary contaminants present in OU2 groundwater at concentrations exceeding the GWSVs. The mobility of metals in groundwater is controlled by the groundwater's geochemistry, the soil's physiochemical properties, and the properties of the metals and associated metal compounds present in the groundwater. The pH and the ORP of OU2 groundwater were measured using a flow-through cell equipped with an interface probe at each MW during each groundwater sampling event. The final stabilization value from each sampling round was averaged to establish the average parameter at each location. Groundwater pH values ranged from 5.8 to 8.2 SUs across OU2. ORP values ranged from -70 to 200 mV in OU2. The groundwater environment at OU2 is primarily an oxidizing environment. Table 5.5.2-1 lists the average geochemical parameters at each MW location. The locally acidic groundwater conditions lead to increased metal solubility in groundwater, which in turn results in the elevated mobility of metals in groundwater.

The groundwater data collected between November 2007 and October 2009 include both dissolved and total metals results, which delineate the extent of metals contamination in groundwater across OU2. The dissolved sample results represent the concentrations of metals fully dissolved in the groundwater matrix. The total metals results may represent the dissolved portion plus particulate matter included in highly turbid samples. [Section 4.2.5](#) discusses the extent of metals in groundwater.

Metals speciation affects the fate and transport of metals in groundwater. However, no metals speciation testing was conducted during the RI, which will be discussed further in [Section 9.5.1](#). Some species of metals behave differently than other species of the same metal. For example, arsenic and chromium have metals species with significantly different fate and transport mechanisms.

The most common forms of arsenic in groundwater are arsenic oxy-anions, arsenite (As^{+3}) and arsenate (As^{+5}). Arsenite is the predominant species in moderately reducing conditions, and arsenate is the predominant species in oxidizing water. OU2 groundwater is slightly oxidizing, with ORP values ranging -70 to 200 mV (OU2 average of 89 mV) and DO concentrations ranging from 0.75 to 9.87 mg/L (OU2 average of 4.25 mg/L). Arsenic tends to partition to soil under oxidizing conditions, and leaching usually does not transport arsenic any significant distance, suggesting that arsenic likely is present as arsenate in groundwater. Arsenate tends to sorb to ferric oxides and is relatively immobile.

Chromium speciates into hexavalent (Cr^{+6}) and trivalent (Cr^{+3}) chromium species as discussed in [Sections 5.3.1](#) and [5.5.1.1](#). The groundwater samples were analyzed for total chromium, which is the sum of the trivalent and hexavalent chromium species. The sorption of hexavalent chromium decreases as pH increases, whereas sorption of trivalent chromium increases as pH increases. Hexavalent chromium can be very soluble and highly mobile in groundwater, while trivalent chromium tends to sorb to particulate matter. Total chromium was detected in both total and dissolved groundwater samples, although total chromium concentrations tended to be higher than dissolved chromium concentrations. This situation suggests that trivalent chromium is the dominant species in groundwater and is sorbed to particulates and filtered out in the dissolved samples. The chromium present in the dissolved groundwater samples may include hexavalent chromium, which is more toxic than trivalent chromium. [Sections 7.0](#) and [8.0](#) provide additional discussion regarding the risk associated with chromium in groundwater.

5.5.2.2 VOCs

VOCs have been detected in OU2 groundwater at concentrations exceeding the GWSVs at two distinct and separate locations along the north side of the Rolling Mill building and near MW10. Four wells (MW04, MW30, MW31, MW33) near the Rolling Mill building contained cVOCs at concentrations exceeding the GWSVs. Three MWs near the Rolling Mill, MW04, MW30, and MW31 are screened in WBZ1, and the remaining well, MW33, is screened in WBZ2. One soil sample, discussed above in [Section 5.5.1.2](#), collected from near the Rolling Mill building contained cVOCs at concentrations exceeding the GWSVs. A historical release of TCE or PCE is suspected to have occurred in this area, and cVOCs have migrated from soil to groundwater. PCE degrades to TCE, which in turn degrades to cis-1,2-DCE and then to VC. Because daughter products have been detected in groundwater in the vicinity of the Rolling Mill, there is some evidence that reductive dechlorination source degradation is occurring (Appendix S-38). As noted in [Section 5.5.2.1](#), the ORP values for OU2 groundwater range from -70 to 200 mV. The average ORP value in wells near the Rolling Mill building is 163 mV, which suggests an oxidizing environment in this area. Oxidizing environments do not support the reductive dechlorination

of PCE to TCE. However, some evidence of degradation exists. Both DCE and VC have been detected in MWs (MW04, MW30, MW31, and MW33) around the Rolling Mill.

Figure 4.2.5-27 shows the maximum detected VOC groundwater concentrations. The highest cVOC concentrations were detected in samples from MW04, which is screened in WBZ1. MW33, which is downgradient of MW04 and screened in WBZ2, yielded samples containing PCE and TCE. This situation suggests that the cVOC contamination has migrated vertically from WBZ1 to WBZ2 and then laterally toward MW33.

VOCs, primarily benzene and ethylbenzene, were detected in MW10, which is screened in WBZ1 along the western side of the former main industrial area. ASTs are located near MW10 and likely are the source of the contaminants. These contaminants were not detected in samples from either of the downgradient wells (WBZ1 well MW27 or WBZ2 well MW28), which suggests that the contamination detected in MW10 is localized and not migrating appreciably. This situation typically is the case with petroleum contaminants, which typically are broken down by biodegradation.

Based on the relatively low VOC concentrations in both areas (near the Rolling Mill and in MW10), it does not seem that VOCs are widespread throughout OU2 or that hydrocarbon light nonaqueous-phase liquid (LNAPL) is present. Therefore, the mobile organic compounds are assumed to be migrating with bulk groundwater flow through advective transport. The extent to which these organic compounds can migrate in groundwater depends on several fate and transport processes. For organic compounds, the most important fate processes are volatilization, photolysis, biodegradation, and sorption. In groundwater, however, volatilization and photolysis are negligible, so the primary mechanisms controlling fate are biodegradation and sorption. Based on the evidence of the cVOCs detected near the Rolling Mill, reductive dechlorination likely is not occurring although a small amount of biodegradation may be occurring. Sorption is controlled by the soil density, soil porosity, K_{OC} , and TOC content of the soil. The K_{OC} is a chemical-specific property, and select values are discussed in [Section 5.1.2.2](#). The TOC, soil density, and soil porosity properties can be measured as discussed in [Section 5.5.1.2](#). The soil at OU2 has low to moderate groundwater permeability, which suggests that sorption is a likely mechanism controlling the fate and transport of VOCs in groundwater.

5.5.2.3 SVOCs, Pesticides, and PCBs

In OU2 groundwater, migration rates and distances from source areas may be significantly limited for SVOCs, pesticides, and PCBs with high partition coefficients (excluding naphthalene and pesticides,

which are moderately soluble and therefore only slightly retarded). Compounds from each of these analyte groups tend to have limited mobility in groundwater because of their tendency to sorb to soils. They are present in groundwater, but based on their limited areas of detection, they do not seem to be migrating in OU2 groundwater.

Naphthalene, which was detected in OU2 groundwater at concentrations exceeding its GWSV, is a relatively mobile PAH in groundwater. Naphthalene sorbs to organic matter in solution and can be transported with groundwater. Naphthalene concentrations exceeded the GWSVs in three geographically separate OU2 wells, MW10, MW22, and MW32, which suggests that although naphthalene may be relatively mobile, it has not migrated over long distances at OU2.

PCB sample results for two wells, MW07 and MW30, exceeded the CRQL. Results for shallow soil samples collected from soil borings in the vicinity of these two wells exceeded the US EPA RSLs. PCBs in soil were localized around Building 100. However, none of the wells in the vicinity of Building 100 yielded groundwater samples with detected PCB concentrations. PCBs strongly sorb to soils and sediments. However, in the presence of organic solvents, PCBs have a tendency to leach through soil and to groundwater. Based on the presence of VOCs in soil samples collected near MW30, it is possible that the organic solvents have pulled PCBs from the soil matrix into solution. Although PCBs were detected in groundwater samples from MW07 and MW30, no other OU2 groundwater wells yielded samples containing PCBs at concentrations exceeding the CRQL.

The presence of mobile contaminants in OU2 groundwater and the hydraulic conductivity of OU2 soils confirm the ability of these contaminants to migrate both vertically from WBZ1 to WBZ2 and laterally in WBZ2. The existing groundwater gradients (flow direction potential) and subsequent discharge points constrain the migration of these materials. However, OU2 groundwater in WBZ1 and WBZ2 is assumed to be discharging to surface water, specifically the LVR. The CSM presented in [Section 6.0](#) further explains the interface between site media such as groundwater and surface water at OU2.

A preferential pathway to consider in the context of potential migration of groundwater is the mine and associated shafts beneath the entire Matthiessen and Hegeler Zinc Company Site. Coal was mined to provide an energy source for the former zinc smelters and on-site kilns. This coal was mined from the Herrin and Colchester Formations (ISGS 1985). The Herrin Formation is the shallower of the two formations and is located at approximately 225 to 250 ft bgs, while the Colchester Formation is located at approximately 300 to 400 ft bgs (ISGS 2009a, 2009b). The WBZ2 shale layer is underlain by limestone bedrock, which is part of the Bond Formation and is located to a depth of 120 ft bgs in the LaSalle,

Illinois area. Based on the deep nature of these mined deposits and the much shallower depths of groundwater in WBZ1 and WBZ2, it is likely that there is no preferential pathway linking WBZ1 and WBZ2 to the mine under the Matthiessen and Hegeler Zinc Company Site. In addition, historical maps show three mine shafts, and attempts were made to ground-truth all of these shafts in 2007, but they were never found. Therefore, the mine shafts are presumed to have been backfilled at some point during the history of the Matthiessen and Hegeler Zinc Company Site.

5.5.3 Potential Migration of Contaminants in Air

Limited air sampling was performed during the OU2 RI. For health and safety purposes, air screening for volatile compounds using a PID was conducted during all soil and groundwater sampling activities. Ambient air samples were collected from areas where asbestos was detected during the RI. ABS was conducted to estimate worker exposure to asbestos materials in soils/solids. Additionally, personal and perimeter air samples were collected to investigate whether asbestos fibers were released into the air during ABS.

Wind erosion of contaminants strongly sorbed to fine surficial soil particles (such as metals) or small particulates (such as asbestos fibers) is possible. Abrasion of soil by animals or trespassers also can release particulates into the air, especially in areas that are not highly vegetated. Depending on soil particulate size, soil cover, and wind conditions, transport may occur through wind erosion or abrasion. The primary wind direction at the Matthiessen and Hegeler Zinc Company Site is south to west-northwest (SulTRAC 2008a). As the finer surficial particles are depleted, potential transport by wind erosion typically decreases over time. Asbestos fibers, especially from former building materials, can be released into the air through disturbance by activity or wind erosion. Note, a general rule is that wind speed increases as the $1/7$ power of the height above ground such that actual wind speeds at ground level are typically quite minimal.

The primary soil/solid contaminants detected at concentrations exceeding the RSLs at OU2 are metals, which are not volatile except for mercury. PID screening was conducted during the RI field activities to evaluate whether volatile contaminants were present in the breathing zone. The PID screening did not detect contaminants in the breathing zone (no readings exceeding 0.0 part per million by volume [ppmv]). The following VOCs were detected at concentrations exceeding the RSLs in OU2 soil, GWSVs in groundwater, and SWSVs in surface water: benzene; bromodichloromethane; chloroform; cis-1,2-DCE; cyanide; naphthalene; PCE; TCE; and VC. Each of these compounds is highly volatile and likely to volatilize to the atmosphere.

The ABS for asbestos was conducted to assess health risks to workers associated with site-related asbestos. The ABS sampling locations were located outdoors at locations where analytical results showed that approximately 1 percent of asbestos fibers were present in surface soil samples collected during Phase I surface soil sampling activities. ABS asbestos samples were collected from each of the following four outdoor locations: former main industrial area, west of Building 100, west of the river pump house, and the southwestern area of the furnaces. The ABS samples were collected from personal sampling pumps in the breathing zone of each worker. In addition, perimeter air samples were collected during the ABS. Results for all of the perimeter air samples analyzed for asbestos fibers were below the detection limit. The ABS personal air samples analyzed for asbestos did not indicate any airborne asbestos at concentrations exceeding the detection limit. Therefore, asbestos fibers are not expected to release under ambient or light work conditions.

5.5.4 Potential Migration of Contaminants in Surface Water and Surface Water Runoff

Surface water may become contaminated through atmospheric deposition, surface water runoff, and groundwater discharge to surface water bodies. The surface water features at OU2 are located in areas of low elevation and fed primarily by surface water runoff. Surface runoff water can erode soil (including slag and debris material) particles and transport these particles in suspension as overland flow for deposition at a lower elevation or to receiving waters, such as the surface water features at OU2 and the LVR. Surface runoff water also can transport dissolved-phase compounds from contaminated soils/solids to receiving waters as a nonpoint source of pollution. Another potential mechanism for volatile contaminant migration in surface water is diffusion. However, diffusion is rarely a dominant transport mechanism unless the water is stagnant.

Table 4.3.2-1 lists the contaminants detected at concentrations exceeding the RSLs in OU2 soil, pile, and building material samples. These contaminants could be transported in surface water runoff. In addition, Table 4.3.2-1 lists contaminants detected at concentrations exceeding the SWSVs. Of these contaminants, the HHRA and ERA (Appendix RA) in [Sections 7.0](#) and [8.0](#), respectively, discuss the ones evaluated to pose a potential or actual risk to human health or the environment.

The surface water features at OU2 mainly are fed by surface water runoff. Each surface water sampling location is associated with a manmade drainage feature. Surface water samples were collected from flowing ephemeral and intermittent streams associated with the abandoned sewer line, standing water bodies, discharge locations from the former main industrial area, and recessed rectangular-shaped foundations where former lead-lined acid tanks were present in the northern portion of OU2. None of the

surface water bodies present at OU2 are typical surface water bodies in that each is ephemeral, fed by surface water runoff, or contained by a manmade structure. Figure 5.5.4-1 shows the OU2 surface water features, preferential drainage pathways, and sampling locations.

The LVR presumably receives some of its water from surface water migration at OU2. Direct contribution comes from a stream that emanates from the underground abandoned sewer line. This sewer line runs west to east across most of OU2, ultimately emptying into the LVR. As shown on Figure 5.5.4-1, the ephemeral streams in the southern portion of the former main industrial area are fed by runoff channeled through a drainage wall that drains a large portion of the former main industrial area. These ephemeral streams do not directly flow into the LVR and terminate at the former railroad grade along the eastern side of OU2. However, because of the nearness of these ephemeral streams to the underground abandoned sewer line and the fact that the abandoned sewer line is located at only 1 to 3 ft bgs (and typically 4 to 5 ft high and 5 to 6 ft in diameter if not collapsed), some surface water likely enters this abandoned sewer line and migrates to the LVR. A percentage of surface water also infiltrates soil or evaporates into the atmosphere. An underground sewer line camera survey was attempted in November 2008 to evaluate the condition of the abandoned sewer. Cameras could not enter the manholes associated with the abandoned sewer line and entered the abandoned sewer line only at the mouth of the stream that discharges to the LVR and continuing approximately 220 ft up to manhole #1 (Figure 5.5.4-1). Purported manholes across OU2 either could not be located for further investigation of the underground sewer line, were collapsed, or were covered with fill. However, all the approximate manhole locations were investigated, and manholes #4 and #5 were assumed to be located beneath the surface water features in the southern portion of OU2. The survey indicated that the abandoned sewer line was constructed of brick and mortar and that water was seeping through the mortar, and also confirmed the internal dimensions of the abandoned sewer line. The survey also documented that the abandoned sewer line was sealed at the western OU2 boundary at Sterling Street.

As shown on Figure 5.5.4-1, the remaining intermittent streams, ponds, and surface water bodies at OU2 are constrained to manmade features (AST basins, foundations, and former tanks), do not discharge to the LVR, and lose water through infiltration or evaporation. As shown in Figure 5.5.4-1, OU2 also contained an intake tunnel that at one time connected to the river pump house. This tunnel was gravity fed from a settling pond next to the LVR. Currently, no evidence of a settling pond was observed nor was any water encountered at the base of the river pump house. In addition, remnants of former railroad tunnels (not shown on Figure 5.5.4-1) exist connecting the former main industrial area to the Slag Pile. Based on an

inspection the tunnels a few discounted puddles exist, but the tunnels are essentially dry and do not appear to be subsurface migration pathways.

Compounds transported in surface water likely are associated with soil/solid particulate matter. The contaminants may remain sorbed to particulate matter that is subsequently transported, desorbed in the water column, volatilized, resorbed to bottom sediments, or carried as suspended sediments until they fall out of suspension. VOCs tend to quickly volatilize to the atmosphere upon reaching surface water and therefore rarely are observed at detectable concentrations in surface water samples. No VOCs were detected at concentrations exceeding the SWSVs in the OU2 surface water samples. SVOCs tend to remain sorbed to particulate matter that is subsequently transported. The fate and transport of inorganic contaminants largely depends on the degree to which contaminated materials can be carried in suspension (which in turn is size-dependent) and on physiochemical conditions, which influences the dominant chemical species.

The OU2 surface water has a neutral pH and a positive ORP, which suggests oxidizing conditions exist. If the geochemistry in surface water changes, it is likely that many of those metals that are in the dissolved phase will be precipitated out of solution.

6.0 CONCEPTUAL SITE MODEL

This section discusses the CSM for the Site. The CSM was developed by integrating technical information from a variety of sources, including the physical characteristics of the Site, the nature and extent of contamination, and contaminant fate and transport pathways. The objective of the CSM was to synthesize current Site data into a conceptual framework that can be used to: 1) guide the evaluation of risks to human health and the environment; and 2) assess appropriate remedial alternatives.

The CSM summarizes the findings presented in [Section 3.0](#), Physical Characteristics of the Site, 4.0, Nature and Extent of Contamination, and 5.0, Contaminant Fate and Transfer. The following sections discuss the CSM for OU1 ([Section 6.1](#)), OU2 ([Section 6.2](#)), and the Site-wide CSM ([Section 6.3](#)).

6.1 OU1 CONCEPTUAL SITE MODEL

The following sections summarize the physical characteristics of OU1, the nature and extent of contamination at OU1, and the contaminant fate and transport at OU1

6.1.1 Physical Characteristics of OU1

The following sections summarize the surface features of OU1, the geology of OU1, and the hydrogeology of OU1.

6.1.1.1 Surface Features

OU1 is bounded to the north by OU2 and is comprised of: 1) the Carus Chemical Plant, 2) a Slag Pile; and 3) the LVR (Figure 6.1.1-1). The operating Carus Chemical Plant is located in the relatively flat western portion of OU1 about 100 ft above the elevation of the LVR. Typical of industrial settings, it consists almost entirely of buildings and paved or asphalt surfaces. The 13.5 acre Plant Area contains numerous buildings associated with the manufacturing process of potassium permanganate and other specialty chemicals. To the east of the Carus Chemical Plant is a 17.7-acre Slag Pile, which reaches a maximum height of approximately 90 ft above the typical level of the LVR. The slag was produced and disposed during the production of zinc metal from ore at the Matthiessen and Hegeler Zinc Company. Based on historical records, the formation of the Slag Pile likely began in the early 1860s and was completed in the early 1960s. The exposed face of the Slag Pile is quite steep and breeches the angles of repose in many places. The steep high banks and little vegetation on the Slag Pile present high erosion

potential. A former railroad bed runs along the western edge of the Slag Pile. Two man-made surface water bodies are present on the facility, the emergency containment pond, immediately adjacent to the east of the Carus facility at the approximate elevation of the former railroad grade, and the holding pond, to the southeast of the Carus facility near the south end of the Slag Pile. To the east of the Slag Pile is the LVR and associated floodplains. The LVR is a bedrock river and part of OU1. It also bounds the eastern and northeastern border of OU2. The river generally runs from north to south toward its confluence with the Illinois River approximately one mile south of OU1. The LVR is a gaining stream (i.e., groundwater generally flows from the aquifer to the river). The river is fairly well confined within a steep, narrow valley formed by glacial melt water and stream erosion. Both banks are composed of a mature wooded riparian corridor except for slag deposits along the southern end of OU2 and continuing into OU1. The river itself has riffle/pool sequences. Riffles are predominately a mixture of gravels and cobbles and typically one to two ft deep at low flow. Pool bottoms are often visible in many areas adjacent to the Site and appear to be three to five ft deep. The channel geomorphology appears stable with no serious instabilities in the channel banks and river bed. The one exception is the 17.7-acre Slag Pile adjacent to the LVR.

6.1.1.2 Geology

The rock and soil beneath OU1 include both natural and man-made deposits of sediment and fill material. Each type of deposit has chemical and hydrogeologic properties which are unique and individually significant to the flow and chemical composition of the shallow groundwater beneath OU1. For this report, these deposits are divided into four general groups on the basis of age and origin. The general subsurface geologic units are shown on Figure 6.1.1-1 and described below:

Pennsylvanian System: The Pennsylvanian System constitutes the bedrock and underlies the entire area around OU1. Within OU1, the Pennsylvanian System consists of horizontal or nearly horizontal layers of shale and limestone with a few thin beds of coal and sandstone. In many areas, a mantle of weathered rock and residual soil has developed within the upper few feet of the Pennsylvanian deposits. Boring logs indicate that relatively thin but highly fractured coal beds may be groundwater transmissive features within the Pennsylvanian System.

Pleistocene Series: The Pleistocene Series is represented by Qly glacial till deposits. Within OU1, this unit is generally confined to the upland areas under the main plant. Although the till is present as approximately 10-ft or 20-ft thick sections in the northwest and northeast corners of OU1, respectively, the till is thinner beneath much of OU1. The till is comprised of coarse and fine till as well as silty clay.

Holocene Alluvium: Alluvial deposits appear to be confined to the valley of the LVR and consist mainly of loose sandy gravel, silty sand, and sandy silt. In the reach of the river that flows by OU1, portions of the alluvial deposits have been buried by deposits of slag.

Fill Deposits: Fill deposits cover large areas of OU1 and include all materials which have been deposited or reworked by human action since the onset of industrial operations. The fill deposits are both complex and significant to the flow (and potentially to the chemistry) of groundwater. Boring logs indicate that fill material is several feet thick in the plant area but thickens toward the east. This facilitates groundwater flow along the sloping top of rock surface toward the east, which is toward the LVR valley. In general, the following types of fill were observed at OU1:

- **Soil Fill** - Soil fill consists primarily of reworked Pennsylvanian shale and glacial till characterized by a loosely compacted jumble of shale and siltstone clods with a small amount of miscellaneous fill material. Other types of fill soils include 1) sediment from the OU1 pond that was placed as fill beneath the reworked shale and till in the Plant Area; 2) structural fill associated with the ICRR grade; 3) miscellaneous shallow fill and road gravel; and 4) the compacted clay liner constructed for the emergency storage area.
- **Sinter Fill** - Sinter, in the context of zinc production, is an intermediate product consisting of agglomerated zinc oxide. The sinter investigated in the fill deposits is presumed to have been off-specification material. Where encountered, the sinter consisted of black, loose granular material, the size of medium sand.
- **Slag Fill** - Slag is the recrystallized or vitrified silicate and oxide residue from the production of metal from ore. Typically, and as observed at OU1, slag ranges in color from moderate red to blackish red and has a highly porous, cindery, vesicular texture. Much of the slag appears to have become welded into large blocks by its own heat prior to and during deposition. Slag deposits observed in outcrops of OU1 were extremely porous with large, interconnected voids on the order of 0.3 to 1.0 ft across. Portions of the slag fill also include various admixtures of miscellaneous debris from the smelting operations including brick and metal debris and pieces of ceramic vessels.

6.1.1.3 Hydrogeology

The hydrogeology of OU1 varies across the different geographic parts of OU1. The three principal geographic areas which comprise OU1 are the Plant Area, the Slag Pile, and the LVR valley (Figure

6.1.1-1). Within these areas there are several hydrogeologic units comprised of the geologic units described above.

Groundwater flow at OU1 is influenced by both geology and topography and can be categorized into two separate WBZ as described below:

- WBZ1 consists of glacial till, fill deposits (fill soil, slag fill, and sinter fill) and alluvium
- WBZ2 consists of the Pennsylvanian bedrock and the weathered surface of the bedrock

The distinction between WBZ1 and WBZ2 is based primarily on hydraulic conductivity data, which indicate that: 1) Pennsylvanian bedrock and weathered surface of the bedrock are not significant groundwater-producing horizons due to their generally low hydraulic conductivities; and 2) there are no significant or widely distributed low permeability horizons (aquitards) above the bedrock. This absence of aquitards above the bedrock results in the groundwater bearing materials within WBZ1 beneath OU1 being effectively a single interconnected system. The differences in hydraulic conductivity and the general slope of the bedrock surface toward the LVR will influence the ease with which water can move in these materials horizontally and vertically; however, there does not appear to be an effective horizon to isolate one hydrogeologic unit from other units. Within WBZ1, the sinter and slag, fill, and Holocene alluvium are the most permeable. The sinter and slag fill is limited to specific areas along the interface of the original bluff of the western side of the LVR valley and the Slag Pile while the Holocene alluvium is limited to the floor of the LVR valley.

Groundwater Flow in WBZ1

Groundwater gradients within WBZ1 indicate groundwater flow trending toward discharge in the LVR valley (Figures 3.2.3-2 and 3.2.3-4). The groundwater gradient for WBZ1 within the Plant Area (mainly fill soil) is relatively flat, and the actual flow of groundwater is likely quite limited due to restricted infiltration of surface water and recharge to the shallow groundwater system due to surface pavement. Recharge to WBZ1 within the Plant Area occurs from precipitation and infiltration in off-site areas primarily to the west of the Plant Area which are not paved or otherwise covered that then flows laterally beneath the Plant Area.

The former erosional gully beneath the eastern part of the Plant Area, now infilled with slag and soil, influences the groundwater in this part of OU1. Groundwater will generally drain toward this filled gully along the top of the lower permeability bedrock surface, eventually draining to the interface of the original bluff of the LVR valley and the Slag Pile.

East of the plant area, pronounced gradients toward the east are measured in the Slag Pile, consistent with gradients observed in the bedrock wells. This suggests that groundwater within the slag materials is travelling along the interface between the slag and the bedrock. Water levels at the base of the slag were difficult to measure as the wells were frequently dry, likely due to the irregular slope of the buried bluff face and the relatively high hydraulic conductivity of the slag. Recharge to the slag materials is through direct precipitation/infiltration, infiltration from the ponds located on the Slag Pile, or from groundwater discharging laterally out of WBZ2 (the Pennsylvanian bedrock) along the bluff face. Locally the slag deposits along the banks of the river are also recharged from the LVR during high river stages.

Wells screened in the alluvial soils in the LVR valley show gradients influenced by the elevation of the adjacent river. The gradients show a trend of lower water levels to the south, downstream, with a component toward the LVR indicating some groundwater flow is likely occurring from the bedrock and through the alluvium and slag to the river. Water level measurements in the LVR and in the interstitial sampling points along the toe of the Slag Pile at the LVR indicate high river levels also result in recharge from the river into the alluvium and river bank deposits, at least locally. These conditions are likely limited to short-term flood events in the LVR.

Vertical gradients assessed at several locations in OU1 indicate that there is a consistent vertical gradient downward from the relatively free-draining slag fill into the underlying material. Likewise, there is an upward vertical gradient between the bedrock and alluvium, which indicates groundwater is discharging from the bedrock into the alluvial deposits. These data suggest that the bedrock is discharging into the valley fill alluvium rather than the water in the alluvium recharging the bedrock groundwater.

Groundwater Flow in WBZ2

Within WBZ2, groundwater gradients exhibit a gradient generally toward the east (Figures 6.1.1-4 and 6.1.1-5) [WBZ2 for September, 2008 and March 2009]. This gradient is likely a combination of the gentle slope of the bedding in the bedrock to the east, and the groundwater flow trending toward discharge along the original bluffs of the LVR valley. The groundwater gradient of WBZ2 within the plant area is relatively flat, and the actual flow of groundwater is likely quite limited due to: 1) the relatively low hydraulic conductivity of the bedrock; and 2) restricted infiltration of surface water and recharge to the shallow groundwater system due to surface pavement. Water levels in the glacial till wells are consistent with the water levels in the Pennsylvanian wells, suggesting these are a single consistent water-bearing zone.

East of the plant area and near the original bluffs of the LVR valley, water levels in WBZ2 indicate a pronounced gradient from west to east, from the uplands to the valley floor. The slope of the water table generally mimics that of the buried, original bluff slope. The locations where the water table deviates from the slope of the bluff face are where the holding pond and emergency basin, constructed on the Slag Pile and railroad grade, offer a source of recharge which masks the water migrating along the bluff slope. Groundwater gradients indicate groundwater discharges from the bedrock along the original bluffs of the LVR valley, recharging the Slag Pile which blankets the slope. Recharge to the alluvial valley fill from bedrock is also suggested by groundwater gradients.

Recharge to WBZ2 occurs from precipitation and infiltration in off-site areas primarily to the west of the plant area which are not paved or otherwise covered that then flows laterally beneath the plant area. Flow within WBZ2 is likely limited to the glacial till and the weathered and fractured uppermost bedrock surface.

6.1.2 Nature and Extent of Contamination

This section discusses the nature and extent of contamination investigated at OU1, which was evaluated with quantitative data from soil, sediment, groundwater, and/or surface water samples. OU1 was divided into the following discreet investigation areas primarily based on geographic location and land use of each area:

- OU1 Area 1 – Plant Area: Soil and groundwater samples were collected from the Plant Area; sediment and surface water samples were not applicable to the Plant Area
- OU1 Area 2 – Slag Pile: Soil, sediment, and groundwater samples were collected from the Slag Pile Area; surface water samples were not applicable to the Slag Pile Area
- OU1 Area 3 – LVR: Sediment and surface water samples were collected from the LVR; soil and groundwater samples were not applicable to this area

Each sample was analyzed for metals, cyanide, PCBs, SVOCs, VOCs, pesticides, and other inorganic compounds (unless otherwise noted). A summary of the analytical results and comparisons to SVs are included in the following sections. The comprehensive analytical results are presented in Appendices G-4-1 through G-4-29.

6.1.2.1 Soil Results

In the Plant Area, arsenic and manganese were the metals most frequently measured above RRSLs and/or IRSRLs in both shallow (<2 ft bgs) and deep (2 to 15 ft bgs) soil samples. Cobalt, mercury, and zinc were also found to exceed the SVs in one sample in the Plant Area. Arsenic exceedances were observed throughout the Plant Area in both shallow and deep samples. Manganese exceedances, however, were observed on the eastern half of the Plant Area in shallow samples and throughout the Plant Area in deep samples. Iron, lead, mercury, and zinc were measured above SVs in shallow soil samples, and cobalt and lead were found to exceed the SVs in deep soil samples.

Benzo(a)pyrene was the SVOC most frequently measured above SVs in shallow soils in the Plant Area. Other SVOCs with concentrations greater than SVs in shallow soils from the Plant Area included benzo(a)anthracene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. In deep soils, SVOC concentrations were detectable but below SVs. The exceedances were noted in only three borings, one at the northwest corner and two near the center of the eastern edge of the plant area.

Detected VOC concentrations were below SVs in both shallow and deep soils while pesticides and cyanide were not detected in either soil horizon. Of the PCBs detected in the Plant Area, Aroclor 1254 and Aroclor 1260 were detected at concentrations above IRSRLs in shallow soils samples. Only one boring exhibited PCB exceedance of the SVs, located near the center of the Plant Area. Although Aroclor 1254 was also detected in deep soil samples, the measured concentrations were below SVs.

In the Slag Pile Area, both shallow (<2 ft bgs) and deep (2 to 109 ft bgs) soil samples were collected. Arsenic, lead, and manganese were the metals most frequently measured above SVs in shallow and deep soil samples. Antimony, cadmium, cobalt, copper, mercury, vanadium, and zinc were also detected at levels above the SVs but less frequently. The exceedances of cadmium, cobalt, mercury, and zinc were observed throughout the Slag Pile Area in both soil horizons. Vanadium concentrations exceeded screening levels only in shallow Slag Pile soils, and antimony concentrations exceeded screening levels only in deep Slag Pile soils.

Benzo(a)pyrene and hexachlorobenzene were the SVOCs measured above SVs in shallow soils from throughout the Slag Pile, while benzo(a)pyrene and dibenzo(a,h)anthracene were most frequently measured above SVs in deep soil samples. Other SVOCs with measured concentrations above SVs in deep soil samples from the Slag Pile Area included benzo(a)anthracene, benzo(b)fluoranthene,

benzo(g,h,i)perylene, and indeno(1,2,3-cd)pyrene. Detected VOC concentrations were below SVs in both shallow and deep soils. PCBs (Aroclor 1254 and Aroclor 1260) and pesticides were detected at levels below SVs in shallow soils, while no PCBs or pesticides were detected in deep soil samples. Cyanide was not detected in either soil horizon.

6.1.2.2 Groundwater Results

The following metals were the metals most frequently measured above Tap Water RSLs and/or MCLs in Plant Area groundwater samples:

- Arsenic
- Cadmium
- Chromium (total)
- Cobalt
- Manganese
- Zinc

Exceedances of metals were observed throughout the Plant Area. Other metals that were measured at concentrations above SVs in groundwater samples from the Plant Area included aluminum, barium, beryllium, iron, lead, mercury, and vanadium. For VOCs, 1,2-dichloroethane and VC were detected above SVs in one groundwater sample from the eastern margin of the Plant Area. For SVOCs, bis(2-ethylhexyl)phthalate was the only COI detected above SVs, and that exceedance was only measured in one well from the eastern edge of the Plant Area. Di-n-butylphthalate was detected in groundwater samples from the Plant Area, but at concentrations less than screening levels. PCBs, pesticides, and cyanide were not detected in groundwater from the Plant Area.

In the Slag Pile Area, groundwater samples were not analyzed for cyanide, pesticides, or PCBs but only for metals, VOC, SVOC, and other inorganic compounds. Arsenic, cadmium, cobalt, and manganese were the metals most frequently measured above screening levels in groundwater samples. The exceedances of these metals were observed throughout the Slag Pile Area in groundwater samples. Other metals with measured concentrations above screening levels from the Slag Pile included copper, iron, lead, mercury, nickel, and zinc in groundwater samples from the Slag Pile Area. VOCs and SVOCs were not detected in groundwater collected from the Slag Pile Area.

6.1.2.3 Surface Water and Sediment Results

In the Slag Pile Area, sediment samples from the holding pond and a seep area originating on OU2 and coming onto OU1 near the middle of the west edge of the Slag Pile were analyzed for metals, VOC, SVOC, PCBs, pesticides, and other inorganic compounds. The metals most frequently measured above RRLs and/or IRLs in sediment samples included the following:

- Arsenic
- Cadmium
- Chromium (total)
- Copper
- Lead
- Mercury
- Nickel
- Zinc

The exceedances were located both in the holding pond and the area adjacent to the seep from OU2 onto OU1, with the exceedances adjacent to the seep typically being greater. Silver was also noted in one sample from the seep area on the west edge of the Slag Pile, but was not detected in the sediments from the holding pond. The only VOC found in sediment samples from the Slag Pile Area was acetone. SVOCs were detected at concentrations exceeding SVs in sediment samples from the Slag Pile. These include sediments from the holding pond and from the seep area with the seep area exceedances being greater. Exceedances were observed for the following SVOCs:

- Acenaphthene
- Acenaphthylene
- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- benzo(g,h,i)perylene
- benzo(k)fluoranthene
- Carbazole
- Chrysene
- Dibenzo(a,h)anthracene
- Fluoranthene
- Indeno(1,2,3-cd)pyrene
- Phenanthrene
- Pyrene

For PCBs, Aroclor 1254 exceeded screening levels in a sample collected from the holding pond and Aroclor 1260 exceeded screening levels in a sample at the seep adjacent to OU2. No other PCBs were detected in sediment samples from the Slag Pile Area. Pesticides were not detected in sediment samples from the Slag Pile Area.

The metals with concentrations most frequently measured above SVs in LVR sediment samples included cadmium, copper, silver, and zinc. Most of these exceedances were observed along the entire stretch of the LVR adjacent to both OU1 and OU2.

The metals with concentrations most frequently measured above SVs in LVR surface water samples included the following:

- Aluminum
- Cadmium
- Copper
- Lead
- Nickel
- Selenium
- Zinc

Aluminum was present only in the total analyses, and below SVs in the dissolved samples, suggesting the exceedances were the result of suspended solids. The majority of the exceedances for cadmium, copper, lead, nickel, and selenium were from the samples at the ASO and CSO discharges. Chromium, iron, and silver were also found to exceed the SVs, but in relatively few samples. Cyanide concentrations were above screening levels in duplicate samples from one location (Section Line DP).

Detectable concentrations of several VOCs were found in sediment and surface water samples collected from 13 sampling locations in the LVR. Acetone was the only VOC that exceeded the SVs, and that exceedance was only noted in the sediment samples from the LVR. Seven different SVOCs were detected above the SVs in sediment from the LVR. These exceedances were from five samples, all of which were at the north end or upstream of the Slag Pile.

SVOCs were not detected in surface water sample collected from the LVR. Aroclors 1242, 1254, and 1260 were detected at concentrations above SVs in sediment samples from the LVR along OU2. PCBs were not detected in surface water samples collected from the LVR. A variety of pesticides were detected in sediment samples above the SVs. All of these sediment pesticide exceedances were upstream of the Slag Pile and the outfall from the ASO. Pesticides were not detected in surface water samples.

6.1.3 Contaminant Fate and Transport

The following sections discuss the potential migration of contaminants in soil, groundwater, air, surface water runoff, surface water, and sediment at OU1.

6.1.3.1 Potential Migration of Contaminants in Soil

The COIs that were detected in soil samples from OU1 in excess of screening criteria included metals, SVOCs, and PCBs. While there is no current use of groundwater at OU1 or downgradient of OU1, contaminants from the soil could migrate to the groundwater. However, the solubility of the SVOCs and PCBs are sufficiently low as to minimize such migration. Additionally, the partitioning to organic matter will further reduce their mobility. Other transport routes include possible fugitive dust generation during excavation or construction activities, and volatilization of mercury. Erosion and transport in surface water is also possible, as discussed below. The mobility of these contaminants from soil to groundwater and air is dependent upon soil chemistry conditions (e.g., soil pH, redox, presence of dissolved organic matter or metal oxides). The redox conditions in the soil may also have an important role in dictating the mobility of most of these inorganic compounds.

6.1.3.2 Potential Migration of Contaminants in Groundwater

The COIs that were detected in groundwater samples from OU1 in excess of screening criteria included metals, VOCs, and SVOCs. Many factors influence the rate of contaminant movement in an aquifer system. These include the physiochemical properties of the contaminants (e.g., solubility, density, viscosity, etc.) and the physiochemical properties of the environment (e.g., soil permeability, porosity, bulk density, particle size distribution, groundwater and soil/sediment geochemical conditions, soil mineralogy, speciation, extent and connectivity of fractures). Because all these factors can affect the rate of contaminant movement through aquifers, it is very difficult to predict contaminant fate and transport.

The presence of these contaminants in groundwater at OU1 and the hydraulic conductivity of the soils at OU1 indicate that these contaminants have the potential to be mobile. The existing groundwater gradients (flow direction potential), nearby discharge points, and lack of current groundwater uses on OU1 constrain the migration and potential of direct exposure to these materials. The gradients evident in OU1 indicate groundwater flow will generally be to the east with potential discharge along the toe of the Slag Pile. Some potential for localized flow to the west is also evident in the extreme western portion of the Plant Area, although this gradient direction may be a seasonal artifact.

6.1.3.3 Potential Migration of Contaminants in Air

Limited air sampling was performed during the RI at OU1. Air samples were collected during a portion of the test for exploration to investigate the limits of the Slag Pile and analyzed for arsenic and lead.

These data did not document the presence of these contaminants in air in excess of screening criteria limits.

6.1.3.4 Potential Migration of Contaminants in Surface Water and Surface Water Runoff

COIs that were observed at levels that exceeded screening criteria in surface water from OU1 consisted only of metals. These compounds may be transported in surface water and surface water runoff since they are likely associated with particulate matter in soil and/or sediments. The contaminants may remain sorbed to particulate matter that is subsequently transported, desorb in the water column, volatilize, or resorb to bottom sediment. The fate and transport of the inorganic contaminants are dependent upon the degree to which the materials can be carried in suspension, which is size dependent, and on physiochemical conditions, which influence the dominant chemical species.

Surface runoff water can erode soil (or slag) particles and transport these in overland flow for deposition at a lower elevation or deliver sediment to receiving waters, such as the LVR. Surface runoff water can also pick up dissolved compounds from contaminated soils and deliver impacted water to receiving waters as a nonpoint source of pollution. Another potential mechanism of contaminant migration in surface water is via diffusion, typically a transport mechanism only in stagnant water.

Slag from the Slag Pile located adjacent to the LVR has the potential to erode into the river and be transported downstream. The slag observed within the river varies considerably in size from sand and gravel to small slag pebbles to large boulders several ft in diameter. Once slag has eroded into the river, the distance the slag travels downstream from the point of entry is influenced by many factors, including particle size and river velocity. Larger slag boulders are anticipated to be located closer to the Site than fine-grained sediment. Smaller particles can be more easily transported downstream. Slag is evident in sediment present at the mouth of the LVR when it discharges into the Illinois River.

6.1.3.5 Potential Migration of Contaminants in Sediments

The COIs that were observed at concentrations above SVs in sediment samples from the LVR or the OU1 ponds included metals, VOCs (limited to acetone only), SVOCs, PCBs, and pesticides. The COIs may remain sorbed to particulate matter that is subsequently transported as suspended sediment, desorb into the water column, volatilize, resorb to bottom or suspended sediments, or leach to the groundwater. The mobility of these contaminants from sediments to groundwater is dependent upon sediment chemistry conditions (e.g., pH, redox, presence of dissolved organic matter or metal oxides). Soluble forms of all the aforementioned contaminants are mobile, but other forms may adsorb to sediments. Redox conditions

in sediments may also have an important role in dictating the mobility of most of the inorganic compounds listed above.

6.2 OU2 CONCEPTUAL SITE MODEL

This section discusses the OU2 CSM including the physical site characteristics, the types of contaminants present in various media sampled, and the significant fate and transport mechanisms that could affect contaminant migration. A discussion of receptors or potential receptors is presented in detail in the human health and ERAs (Appendix RA). A graphical representation of the OU2 CSM is shown in Figure 6.2.1-1. Each of these items is discussed below. The following sections discuss the physical characteristics ([Section 6.2.1](#)), nature and extent of contamination ([Section 6.2.2](#)), and contaminant fate and transport ([Section 6.2.3](#)) at OU2.

6.2.1 Physical Characteristics of OU2

This section discusses the physical characteristics of OU2 including surface features, site geology, and site hydrogeology. Each of these physical characteristics is discussed below.

6.2.1.1 Surface Features

OU2 is bounded to the north by woodlands, to the south by OU1, to the west by residences, and to the east by the LVR (Figure 6.2.1-1). A former railroad bed runs along the eastern edge of OU2 and creates a border between OU1 and OU2 in the southeast corner of the property. Topographically, the Matthiessen and Hegeler Zinc Company Site spans approximately 160 ft in elevational difference. The low point is the LVR at 456 ft above msl, in the south eastern portion of the Site. The high point is 613 ft above msl located in the northern portion of OU2, which is just southeast of the off-site rectangular building (Apollo Works) located in the very northwest corner of Figure 1.2.1-1. The central portion of OU2 is referred to as the former main industrial area and it comprises most of OU2's area. Woodlands dominate the north and northeast periphery of OU2. Specifically, the northern area is characterized as a disturbed woodland-grassland with some savannah, and the northeastern portion is characterized as oak-hickory woodland.

In the former main industrial area of OU2, the surface topography is highly disturbed, with little or no vegetation present. In this area, over 100 abandoned buildings either have been demolished or have collapsed from disrepair. As a result, this central area is covered with pits at excavated and crumbling building foundations, ASTs, AST foundations, sinter and slag deposits, scattered piles of waste and building debris (clay pipes, sinter, slag, soils, etc.), twisted metal and wood ties from old rail spurs,

abandoned railcars, and in-ground former sulfuric acid tanks. OU2 contains the following standing but deteriorating structures: the Rolling Mill, Building 100, a deep well pump house, shallow pump houses, a river pump house, former furnaces, former brick-lined kilns, a former stone pottery building, and a former oxide plant. Building demolition, waste deposition, and subsequent redistribution of wastes, debris, and native soils have created a rough, unnatural topography. For example, the topography in the former main industrial area ranges from a high of approximately 607 ft above msl near two circular former acid tanks located in the northern portion of the area to a low of 537 ft above msl between the furnaces and the Slag Pile.

These alterations in the local topography have subsequently altered on-site drainage networks. Using aerial photographs and detailed site land surveys, potential water features were investigated in this central area of the Matthiessen and Hegeler Zinc Company Site. Ephemeral channels, pools, and ponds typically form around slag and debris piles and building foundations and usually are present after rain events or when a water depression is blocked by a road crossing or vegetation. Although ephemeral by nature, these channels, pools, and ponds drain the disturbed central area landscape. The substrate for these ephemeral channels, pools, and ponds typically consists of eroded sinter, slag, or fill, building materials, and minor soils or organic debris. However, enough organic debris has accumulated in some areas to support some vegetation growth.

The central area is open, and most of it is topographically higher than the former railroad tracks that extend north to south along the entire east side of the Matthiessen and Hegeler Zinc Company Site. The former ICRR grade ranges in elevation between 556 ft above msl in the northern portion of the Site to 536 ft above msl just west of the Slag Pile. The surface topography slopes dramatically from the former railroad grade to the LVR to the east. Weathered bedrock shale and limestone outcrops are visible along the forested/vegetated corridor sloping toward the LVR, and small seeps have been observed just west of the Slag Pile and just south of OU2.

The eastern and northeastern border of the entire Matthiessen and Hegeler Zinc Company Site is bounded by the LVR and associated floodplain. The LVR is a bedrock river and part of OU1. The LVR floodplains are narrow and contain a mixture of upland and bottomland or water-tolerant plants. The LVR is fairly well confined within a steep, narrow valley formed by glacial melt water and stream erosion. Both banks are composed of a mature wooded riparian corridor except for slag deposits along the southern end of OU2 and along the Slag Pile. The LVR itself has riffle/pool sequences. Riffles are predominately a mixture of gravels and cobbles and typically 1 to 2 ft deep at low flow. Pool bottoms are often visible in many areas alongside the Matthiessen and Hegeler Zinc Company Site and appear to be 3

to 5 ft deep. The channel geomorphology appears stable, with no serious instabilities in the channel banks and bed. The one exception is the 17.7-acre Slag Pile next to the LVR.

6.2.1.2 Geology

The rock and soil beneath OU2 include both natural and manmade deposits of soil and fill material (Figure 6.2.1-1). Geologic units include the Pmc and two sequences from the Quaternary System, the Pleistocene Series (Qly) and the Qe.

In general, the geology at the Matthiessen and Hegeler Zinc Company Site is composed of Pennsylvanian-aged bedrock overlain by Quaternary-aged sediments and manmade or reworked materials. The unconsolidated Quaternary materials are heterogeneously deposited as there are many manmade fill deposits, indicating deposition, excavation, and reworking of much of the surface of OU2. The OU2 landscape was also dominated by both glacial and fluvial activity during the late Holocene as documented by the soil boring logs. Each unit is discussed in more detail below.

Bond Formation of the Pennsylvanian System (Pmc): The Pennsylvanian-aged bedrock at OU2, consists of the Pmc. The Pmc is regionally characterized by a high percentage of limestone and calcareous clays and shales (ISGS 1975). Red claystones and shales are present in this formation and best developed in northern Illinois as seen on OU2 (ISGS 1975). The Pmc is a horizontally bedded calcareous red and gray-green shale or claystone underlain by gray fossiliferous limestone interbedded with coal seams and gray shale or claystone.

Underlying the red and gray shale bedrock is the gray fossiliferous limestone. The Pmc limestone contains interbeds of shale or claystone which range from 0.04 to 0.5 inches thick as well as coal seams which range from approximately 0.25 inch to 2 ft thick. Small fossils (including brachiopods, crinoids, bryophyte, calcite-filled vugs) were observed in the Pmc limestone. In addition, cyclothems were observed in deep borings in OU2. In general, the Pmc shale typically appears moderately to extremely fractured both in contact with the overlying younger formations and the underlying limestone. Trace silt in some of the fractures within the shale suggests that water flows through these fractures. Both the Pmc upper shale contact and the Pmc lower shale/upper limestone contact show weathering in some soil boring locations on OU2. The Pmc shale member was seen as shallow as 592.77 ft above msl and the Pmc limestone member was documented as deep as 483.18 ft above msl. None of the on-site borings were deep enough to penetrate the entire thickness of the limestone member.

Lemont Formation: The Qly is ubiquitously present across OU2. The predominant clast lithologies consist of Paleozoic shales and carbonates. Locally, Qly includes a glacial till facies that is typically gray to brown/tan in color and calcareous, and that has a grain size ranging from silty clay to sandy loam to gravel. The Qly has been interpreted as subglacial and ice-marginal facies of several off-lapping, glaciogenic sequences. The Qly unconformably overlies the Pennsylvanian bedrock. Soil boring logs describe the predominant presence of silty clays, sandy gravels, and sandy loams which extend over the majority of OU2. The Qly extends from 607.96 ft above msl to 564.86 ft above msl. Typically, the Qly extends down to approximately 580 to 578 ft above msl across the majority of OU2 where it contacts the Pmc. However, in the topographic low areas, near the Rolling Mill and north of the furnaces, the contact is documented 10-14 ft lower.

Equality Formation: The Qe consists of lacustrine sediment deposited in glacial and post-glacial lakes of brown to gray to red, bedded silt and clay. The Qe unconformably overlies the Pennsylvanian bedrock and extends over the southern portion of OU2 (not shown on Figure 6.2.1-1). This situation suggests that in this area, erosion, possibly glacial or fluvial, removed some of the Pmc and all of the Qly lithologies prior to the deposition of Qe. The Qe is discontinuous and thin (29 ft thick), ranging from 560.5 ft above msl to at least 531.23 ft above msl, which is the deepest boring measurement obtained for this formation, although no contact between the Qe and the Pmc was observed or noted.

Artificial Fill Deposits: Artificial fill deposits (Qaf) cover large areas of OU2 and include all materials deposited or reworked by human action since the onset of industrial operations. The fill deposits are complex and very significantly affect groundwater flow (and potentially groundwater quality). The fill along the perimeter of OU2 extends from 0.5 ft bgs to 4.5 ft bgs. The thickest fill deposit extends to 33.5 ft bgs at MW27. The varying thickness of fill material logged around OU2 indicates that the sinter and slag material was used both as construction material and disposed of or backfilled in topographically low areas. OU2-specific fill material consists mainly of sinter; slag; small pieces of building debris (brick, stone, mortar, etc.); reworked soil; glacial tills and other Quaternary-aged sands, silts, and clays; and reworked Pennsylvanian-aged shale and limestone.

Sinter, in the context of zinc production, is an intermediate product consisting of agglomerated zinc oxide. The sinter investigated in the fill deposits is presumed to have been off-specification material. Where encountered, the sinter consisted of black, loose granular material the size of medium sand. Slag is the recrystallized or vitrified silicate and oxide residue from the production of metal from ore. Typically and as observed at OU2, slag ranges from moderate red to blackish red and has a highly porous, cindery, vesicular texture. Much of the slag appears to have welded into large blocks by its own heat prior to and

during deposition. Soil fill consists primarily of reworked Pennsylvanian shale and glacial till characterized by a loosely compacted jumble of shale and siltstone clods mixed small pieces of building material debris. Building material debris includes concrete, brick, glass, and wood.

6.2.1.3 Hydrogeology

The hydrogeology of OU2 varies across the different geographic parts of OU2. Groundwater flow at OU2 is influenced by both geology and topography and can be categorized into two separate water-bearing zones as described below:

- WBZ1 consists of unconsolidated materials;
- WBZ2 consists of underlying shale bedrock and the top of the limestone bedrock.

Groundwater Flow in WBZ1

The potentiometric surface drawings in [Section 3.3](#) show that the WBZ1 is a continuous system in the unconsolidated overburden material, with most groundwater flow to the east and southeast. The WBZ1 gradient is relatively flat to the southeast over most of OU2. A steeper gradient exists to the east, which coincides with a 30- to 40-ft decrease in elevation in this portion of OU2.

In the central portion of OU2, the unconsolidated materials comprising WBZ1 consist of fill materials such as slag, sinter, brick, and other construction debris. These materials are not compacted, highly variable, and tend to be more porous, with a higher permeability. [Section 3.3.3.2](#) discusses the groundwater flow in WBZ1 in more detail. WBZ1 is recharged by direct precipitation and infiltration in areas that are not paved or otherwise covered. In addition, OU2 surface water, which is composed of ephemeral streams, ponds, and pools, likely infiltrates WBZ1.

Groundwater Flow in WBZ2

The potentiometric surface drawings in [Section 3.3](#) show that WBZ2 has a fairly consistent gradient in the former main industrial area, with groundwater flow in an easterly direction towards the LVR. In the southern portion of OU2, the gradient in the vicinity was steeper and in the northeast direction. Although at the surface the topography is fairly flat, a bedrock valley, potentially an erosional surface, is indicated via soil boring descriptions and drawn cross-sections, in this area of the Site. This change in bedrock surface elevation could account for the steeper groundwater gradients in the vicinity of MW32, MW33,

and MW05. A steeper gradient exists to the east near MW18, which coincides with a 60 to 70 ft bedrock bluff.

The WBZ2 aquifer consists of moderately fractured shale and limestone, and the aquifer is assumed to discharge into the LVR. [Section 3.3.3.2](#) discusses the groundwater flow in WBZ2 in more detail. WBZ2 is recharged by water traveling vertically downward from WBZ1. Flow within WBZ2 is mostly constrained to the fractured shale and weathered limestone bedrock surface.

6.2.2 Nature and Extent of Contamination at OU2

This section summarizes the nature and extent of contamination investigated at OU2, which was evaluated based on quantitative data from soil, building material, pile, groundwater, surface water, and air samples. OU2 was divided into discrete investigation areas primarily based on geographic location and the land use in each area for soil, building material, pile, and air samples. For the groundwater samples OU2 was not divided based on geographical location. Instead, OU2 groundwater samples are discussed with respect to the WBZ from which each sample was collected. For the OU2 surface water samples, OU2 was not split into separate investigation areas or WBZs. The investigation areas used to discuss soil, building material, pile, and air samples include the following:

- Investigation Area 1: Building 100 – Soil, building material, pile, and air samples were collected from this area.
- Investigation Area 2: Rolling Mill – Soil, building material, pile, and air samples were collected from this area.
- Investigation Area 3: Former Main Industrial Area – Soil, building material, pile, and air samples were collected from this area.
- Investigation Area 4: North Area/Northeast Periphery Area – Soil samples were collected from this area. Building material, pile, and air samples were not collected from this area.
- Investigation Area 5: Residential Area/Off-site Area – Soil samples were collected from this area. Building material, pile, and air samples were not applicable to this area.
- Background Area: Soil samples were collected from the background area. Building material, pile, and air samples were not collected from the background area.

The following sections summarize the analytical results and comparisons to SVs. [Section 4.3.2](#) and Table 4.3.2-1 provide complete summaries of the OU2 data.

6.2.2.1 OU2 Soil/Solid Results

For OU2, the term “soil/solid” includes solid matrix materials comprising the surface and subsurface deposits. These solid matrix materials consist of: 1) natural soils; 2) unconsolidated Quaternary-aged sedimentary deposits, some of which have been reworked; 3) manmade fill, slag, sinter, and other by-products of zinc smelting operations; and some fraction of brick, ceramic, and other building debris disposed of along with the sinter and slag materials; and 4) Pennsylvanian-aged shale and limestone bedrock, some of which have also been reworked and redeposited with the above mentioned fill materials. The OU2 soil/solid results are summarized below.

	Solid Matrix Type	Inorganic Analytes Above RSLs	Organic Analytes Above RSLs	Comments
Investigation Area 1	Soil	Arsenic, Cadmium, Cobalt, Manganese, Mercury, Lead, Zinc	SVOCs, PCBs, Asbestos	Highest lead detected near Building 100 and east central part of Investigation Area 1; highest SVOCs and PCBs detected along eastern side of Building 100.
	Building Material	Arsenic	NA	All building material samples exceeded RSLs for arsenic; one PCB exceedance from concrete sample from near Building 100.
	Pile	Arsenic, Cadmium, Lead, Zinc	SVOCs	All pile samples exceeded RSLs for arsenic and lead; one PCB exceedance from concrete sample from near Building 100.
Investigation Area 2	Soil	Arsenic, Cadmium, Cobalt, Manganese, Lead, Zinc	SVOCs, PCBs	Highest lead detected near north-northeast corner of the Rolling Mill; highest VOCs detected near northwest corner of the Rolling Mill; highest SVOCs detected near west-central portion of Investigation Area 2; highest PCBs detected near northwestern corner of the Rolling Mill.
	Building Material	Arsenic	NA	All building material samples exceeded RSLs for arsenic near Rolling Mill.

	Solid Matrix Type	Inorganic Analytes Above RSLs	Organic Analytes Above RSLs	Comments
	Pile	Arsenic	SVOCs	All pile samples exceeded RSLs for arsenic.
Investigation Area 3	Soil	Antimony, Arsenic, Cadmium, Cobalt, Copper, Lead, Manganese, Mercury, Zinc	SVOCs, PCBs, Asbestos	Highest cadmium detected in west-central portion of Investigation Area 3; high lead and SVOCs encompasses all of area; highest mercury exists near the west, central, and northeast portions of area; highest PCBs exists in two small areas area.
	Building Material	Antimony, Arsenic, Cadmium, Chromium, Lead, Mercury, Zinc	SVOCs, Asbestos	Highest arsenic detected near former kilns; highest lead detected near former System-5 building; highest SVOC results are from wood samples collected throughout Investigation Area 3; highest asbestos detected near former acid reservoir on north side of area.
	Pile	Antimony, Arsenic, Cadmium, Cobalt, Copper, Iron, Lead, Manganese, Mercury, Thallium, Zinc	SVOCs, PCBs, Pesticides, Asbestos	Highest arsenic detected on the southern edge of the System 3 building in a former coke crushing area; highest lead detected near the northwest corner of the former System 5 building; Highest SVOCs detected on eastern side of Investigation Area 3 near former furnaces; highest PCB detected in southwest corner of area, east of Rolling Mill; highest asbestos detected near former acid reservoir on north side of area.

	Solid Matrix Type	Inorganic Analytes Above RSLs	Organic Analytes Above RSLs	Comments
Investigation Area 4	Soil	Arsenic, Cadmium, Cobalt, Lead, Manganese, Zinc	SVOCs	Highest lead detected in the central portion of Investigation Area 4 bordering the northern portion of Investigation Area 3; highest metals concentrations detected in Investigation Area 4 closest to the former main industrial area and along the southern and southwestern borders of Investigation Area 4; SVOCs were the only organic compounds detected in soil.
Investigation Area 5	Soil	Arsenic, Cadmium, Lead, Zinc	NA	<p><u>Residential:</u> Arsenic exceeded RSLs in all residential areas of Investigation Area 5; highest cadmium detected in the residential area up to 650 ft west of Site; highest lead concentrations were detected in the southeastern portion of residential area.</p> <p><u>Off-site:</u> Arsenic concentrations exceeded RSLs in all off-site areas of Investigation Area 5; high cadmium detected throughout off-site area; highest lead detected approximately 2,000 ft southwest of the Site; highest zinc detected in the northern portion of off-site area; highest manganese detected in the northern portion of the off-site area.</p>

6.2.2.2 OU2 Groundwater Results

Groundwater samples were collected from MWs installed in both water bearing zones (WBZ1 and WBZ2) investigated at the Site. The analytical results for groundwater samples collected in WBZ1 and WBZ2 are summarized below.

	Matrix	Inorganic Analytes Above RSLs	Organic Analytes Above RSLs	Comments
WBZ1	Groundwater	Arsenic, Cadmium, Cobalt, Iron, Lead, Manganese, Mercury (total only), Selenium, Thallium (total only), Zinc	VOCs, SVOCs, Pesticides	High metals concentrations were detected throughout WBZ1 groundwater; highest VOCs detected in wells on northern side of Rolling Mill; SVOCs detected in northern portion of former main industrial area and detected near empty ASTs northeast of Building 100.
WBZ2	Groundwater	Arsenic, Cadmium (dissolved only), Cobalt, Lead (total only), Manganese, Zinc (dissolved only)	VOCs, SVOCs, Pesticides	High metals concentrations were detected throughout WBZ2 groundwater; highest VOCs detected in well on southeast corner of Rolling Mill.

6.2.2.3 OU2 Surface Water Results

The OU2 surface water samples were collected from intermittent or ephemeral streams, drainage or sewer lines, and areas of standing water. The analytical results for samples collected in OU2 surface water are summarized below.

Matrix	Inorganic Analytes Above RSLs	Organic Analytes Above RSLs	Comments
Surface Water	Arsenic, Cadmium, Cobalt, Iron, Lead, Mercury, Silver, Zinc	Pesticides	High metals concentrations were detected throughout surface water samples.

6.2.2.4 OU2 Air Results

Two asbestos air sampling events were conducted to assess exposure and risks associated with asbestos inhalation at OU2. The passive sampling event was conducted on July 9, 2008, and the ABS event was conducted on September 30, 2009. None of the sample results from either sampling event tested positive for asbestos above the detection limit, which ranged from 0.005 to 0.006 f/cc.

6.2.3 Contaminant Fate and Transport at OU2

The following sections discuss the potential migration of contaminants in soils/solids, groundwater, air, surface water, and surface water runoff at OU2.

6.2.3.1 Potential Migration of Contaminants in Soils/Solids

The contaminants of concern detected in soil/solid samples from OU2 at concentrations exceeding the SVs included metals, VOCs, SVOCs, PCBs, pesticides, and asbestos. As shown in Figure 6.2.1-1, the predominant migration routes for contaminants in soil include: 1) migration from soil to groundwater; 2) transport with surface water runoff; and 3) transport as wind-blown particulates. To a lesser degree, volatilization of VOCs and mercury may also be occurring. The likely migration route for these contaminants is from soils/solids to groundwater. Erosion and transport in surface water and surface water runoff also are possible as discussed below in [Section 6.2.3.4](#). The mobility of contaminants migrating from soils/solids to groundwater and air depends on soil chemistry conditions (such as soil pH, redox, and presence of dissolved organic matter or metal oxides). Soluble forms of all the contaminants detected in the soil/solids samples are relatively mobile, but other forms may adsorb to sediments or soils. The redox conditions in soil may also have an important role in dictating the mobility of most inorganic compounds.

6.2.3.2 Potential Migration of Contaminants in Groundwater

The contaminants of interest detected in OU2 groundwater samples from both WBZ1 and WBZ2 at concentrations exceeding GWSVs included metals (total and dissolved), VOCs, SVOCs, and pesticides. As shown in Figure 6.2.1-1, the predominant migration routes for contaminants in groundwater include lateral migration in WBZ1 and WBZ2, and vertical migration from WBZ1 to WBZ2. As indicated in Figure 6.2.1-1, groundwater likely discharges to the LVR. The nature of the contaminants in groundwater and the hydraulic conductivity of soils at OU2 indicate that these contaminants have the potential to be moderately mobile. WBZ1 is composed of poorly compacted, highly variable soil materials that tend to have a higher permeability than WBZ2 soils. The OU2 gradients indicate that groundwater generally will flow in an eastward direction towards the LVR, with potential discharge to the LVR. Groundwater contaminants at OU2 could be transported in groundwater, but the movement of these contaminants would be controlled by the physiochemical properties of the individual contaminants as discussed in [Section 5.5.2](#).

6.2.3.3 Potential Migration of Contaminants in Air

Limited air sampling was performed during OU2 RI activities. For health and safety purposes, air screening for volatile compounds using a PID was conducted during all soil and groundwater sampling activities. Ambient air samples were collected from areas where asbestos was detected during the RI. ABS was conducted to estimate worker exposure to asbestos materials in soil. Additionally, personal and perimeter air samples were collected to evaluate whether asbestos fibers were released into the air during ABS. Data from these activities did not indicate the presence of contaminants in air at concentrations exceeding the detection limit, which ranged from 0.005 to 0.006 f/cc.

6.2.3.4 Potential Migration of Contaminants in Surface Water and Surface Water Runoff

The surface water features at OU2 mainly are fed by surface water runoff. Many of the surface water sampling locations are associated with a manmade drainage features. Surface water samples were collected from flowing ephemeral and intermittent streams associated with the abandoned sewer line, standing water bodies, and a discharge wall from the former main industrial area. Surface water was also collected from a recessed rectangular-shaped foundation where former lead-lined acid tanks are present in the northern portion of OU2 and from a manmade basin containing an AST. Additionally, two water bodies not associated with any flowing intermittent streams or manmade structures were sampled: an intermittent pool in the former main industrial area and an ephemeral wetland-type (topographic low with tall reeds – not officially classified as a wetland) pond just north of the former main industrial area. None of the surface water bodies present at OU2 is a typical surface water body, in that each is ephemeral, fed by surface water runoff, or contained by a manmade structure.

As shown in Figure 6.2.1-1, surface water runoff may transport contaminants to other portions of OU2 or to the LVR. Surface water in “contained” structures such as recessed former acid tank foundations is not expected to migrate as runoff; however it may infiltrate into soil if the foundations are cracked and leaking. Surface water in ephemeral and intermittent streams may transport contaminants to low lying areas within OU2; however, these upland streams do not lead directly off-site to the LVR. As indicated in Figure 6.2.1-1, a potentially significant surface water migration pathway is the stream emanating from the abandoned sewer line which could transport contaminants from OU2 to the LVR.

Compounds transported in surface water likely are associated with particulate matter in soils/solids. The contaminants may remain sorbed to particulate matter that is subsequently transported, desorbed in the water column, volatilized, or resorbed to bottom sediments, or carried as suspended sediments until they

fall out of suspension. VOCs tend to quickly volatilize into the atmosphere upon reaching surface water and for this reason rarely are observed at detectable concentrations in surface water samples. No VOCs were detected at concentrations exceeding the SWSVs in the surface water samples. SVOCs tend to remain sorbed to particulate matter that is subsequently transported. The fate and transport of inorganic contaminants depend on the degree to which the contaminants can be carried in suspension, which is size-dependent, and on physiochemical conditions, which influences the dominant chemical species. OU2 surface water has a neutral pH and a positive ORP, which suggests oxidizing conditions. If the geochemistry of surface water changes, many metals in the dissolved phase likely will precipitate out of solution.

6.3 SITE-WIDE CONCEPTUAL SITE MODEL

The following section summarize the following aspects of the site-wide CSM:

- Physical characteristics
- Geology
- Hydrogeology
- Surface water
- Nature and extent of contamination
- Contaminant fate and transport

6.3.1 Physical Characteristics

Several major features comprise the physical character of the Matthiessen and Hegeler Zinc Company Site (Figures 6.1.1-1 and 6.2.1-1). The active Carus Chemical Plant occupies the southwestern portion of the Site, within OU1. This plant is an operating chemical manufacturing facility comprised of numerous buildings and paved areas. Since the pre-NPL listing investigations in the early 1990's, additional paving has occurred in the Plant Area so that today the extent of unpaved areas is very small. The active manufacturing at the Carus Plant is not related to the contamination under investigation as part of this RI.

The Slag Pile occupies the western bank of the LVR and is part of OU1. The material in the Slag Pile was placed in its present location between the 1860's and the early 1960's during the zinc smelting operations of the Matthiessen and Hegeler Zinc Company. The Slag Pile extends nearly 3,000 ft along the river bank. Portions of the Slag Pile have been eroded into the LVR and slag is visible in the river sediment to the confluence with the Illinois River approximately one mile downstream from the Slag Pile.

The LVR is considered part of the Site, due to its proximity to both OU1 and OU2, and the presence of slag in the river sediments. The LVR flows from north to south adjacent to the Site, drains a watershed of approximately 125 square miles, and experiences a considerable range of river stages following precipitation events in the basin. The river contains a variety of fluvial environments, from relatively slow flowing pools to more turbulent rapids and riffles. During flood stages, the river can be 6 to 10 ft above normal pool stage, as evidenced by debris in vegetation along the river banks.

A large portion of the upland area of the Site is occupied by the former zinc smelter operations, which compromises the main portion of OU2. This area is characterized by extensive ruins of the former smelter buildings, and debris and waste materials from the smelting operations, including asbestos, sinter, and slag. Several vessels containing water are also present in this area. Other operations included sulfuric acid production and a zinc Rolling Mill.

The area adjacent to the former smelter operations also includes the former zinc Rolling Mill, which is currently used for storage and warehousing. This building is no longer in use as part of the zinc smelting and processing operations of the Matthiessen and Hegeler Zinc Company or the former zinc Rolling Mill operation.

In addition to the LVR, surface water features on the Site include an emergency containment pond and cooling water holding pond on OU1, and ephemeral streams and pools in OU2. The cooling water holding pond, located at the south end of the Slag Pile Area, and the emergency containment pond, located at the west-central portion of the Slag Pile Area, are connected to the Carus Plant through underground piping and discharge to the LVR through a permitted NPDES discharge. The ephemeral streams and standing water ponds on OU2 do not normally drain to the LVR, but either infiltrate into the soils or drain into various storm water drop structures present in OU2. The storm sewers are thought to connect with the ASO which discharges on the eastern part of OU2 and immediately upstream of CAR003 ([Section 8.1.2](#)). A small tributary stream connects the ASO to the LVR. Another sewer outfall is also located immediately adjacent to the LVR. The City of LaSalle operates a CSO that is present in OU2 along the LVR near the north end of the Slag Pile and immediately upstream of CAR003 ([Section 8.1.2](#)). Other underground structures include a water line connecting the LVR to a water supply well within the smelter operations area within OU2.

With the exception of the Carus Plant Area which is paved and covered with buildings, much of the rest of the Site is covered by deciduous and herbaceous vegetation, in particular in the northern and southern portions of the Site. Additionally, the banks of the LVR have developed vegetative cover. The bluffs of

the LVR valley are well vegetated where not covered with slag. Portions of the Slag Pile have also developed a vegetative cover, particularly on the top of the Pile, although much of the steeper slopes above the LVR are barren of vegetation. Large portions of OU2 in the former smelter operations are also barren of vegetation.

6.3.2 Geology

The geology of the Matthiessen and Hegeler Zinc Company Site consists of the Pennsylvanian age bedrock overlain by glacial and lakebed deposits, alluvial riverbed deposits along the LVR, and artificial fill deposits consisting of soil and debris deposited by man. These deposits are briefly summarized below.

The Pennsylvanian age bedrock is represented by the McLeansboro Group which underlies the Site and surrounding vicinity. These deposits include limestone, shale and thin coal beds. These units are relatively flat-lying, with a gentle dip toward the east. The rocks are not developed as water-bearing units in the vicinity of the Site. These rocks are well exposed along the bluffs which form the LVR valley, except where the Slag Pile is adjacent to, and obscures the view of, the bluffs.

The Pleistocene age deposits include the glacial Qly and the lacustrine Qe. The Qly is a glacial till, present on the uplands under OU1 and OU2. The deposits are relatively thin and discontinuous, consisting of silty, sandy and gravelly clay till. The material is locally coarse grained and those areas may be water-bearing. The till is located directly on top of the Pennsylvanian bedrock.

The Qe is a quiet water lakebed deposit. This material is apparently restricted to OU2, and is present in the low areas near the center of the Site. The deposits are fine-grained silt and clay deposits, which may have lower hydraulic conductivities due to the fine grain size of the material.

The youngest naturally occurring deposits are the stream bed alluvial deposits in the LVR valley. These materials may include glacial age outwash deposits from the glacial melt waters, but are generally recent age deposits from the current river. The materials are silty to clayey sand and gravel deposits, and can include some large bedrock boulders. In the vicinity of the Slag Pile, the sediment in the river includes sand to boulder size slag materials.

The artificial fill materials are those laid down by the works of man. These include the soil fill used to construct the former railroad bed along the east parts of OU1 and OU2, the Slag Pile, the debris and waste materials present over much of OU2, and fill soil, sinter or slag placed to fill former drainages along the

edge of the bluffs. These materials range from relatively pure slag deposits in the Slag Pile, to engineered fill soil deposits along the former railroad bed. Portions of the filled areas consist of mixtures of soil and slag, and much of the OU2 area is covered by a mixture of slag, waste materials, debris from the smelting and coal mining operations, and soil fill. These artificial fill materials tend to be relatively loose and exhibit higher hydraulic conductivities than the naturally occurring soils and bedrock deposits. This higher hydraulic conductivity influences the groundwater migration and contaminant transport.

6.3.3 Hydrogeology

The hydrogeology of the Site is characterized by two WBZs. WBZ1 consists of the surficial deposits of glacial till, lake bed silt and clay, the river bed sand and gravel alluvium, and the artificial fill comprised of slag, debris and miscellaneous fill soils. WBZ2 is comprised of the Pennsylvanian bedrock units.

WBZ1 (Figure 6.3.3-1) shows a gradient generally draining to the east. The gradient increases near the bluffs of the bedrock, likely evidence of discharge along the banks of the LVR. Recharge to WBZ1 is primarily through infiltration of precipitation, locally from seepage from the ponds and surface water bodies, including bank recharge from the LVR during high river stages. Hydraulic conductivity of the WBZ1 materials are in the range of 2.0×10^{-1} to 1.6×10^{-4} cm/sec.

WBZ2 (Figure 6.3.3-2) consists of the Pennsylvanian bedrock units. Some of these units may have higher hydraulic conductivities due to weathering and fractures near the top of rock, or within some of the coal beds, but these materials are generally lower conductivity than the overlying WBZ1 materials, in the range of 7.9×10^{-4} to 2.2×10^{-6} cm/sec. The lower hydraulic conductivity is such that these deposits are not developed for water supply wells in the vicinity of the Site.

The gradient in WBZ2 generally trends to the east as does WBZ1, suggesting discharge out of the bluff face beneath the surface of the Slag Pile or along the bluffs where the Slag Pile is not present. Discharge was also evident from the bedrock into the overlying alluvial deposits in nested wells. Recharge to these bedrock units is likely through infiltration from the overlying WBZ1 units, or direct infiltration where the bedrock is exposed at the ground surface. Locally, in the LVR valley sediments, the vertical gradients between wells in WBZ1 and WBZ2 indicate some flow from the bedrock upward into the overlying alluvium deposits.

6.3.4 Surface Water

Surface water on the Site consists of isolated ephemeral streams and standing water pools, constructed ponds as part of the Carus Plant operations, and the major surface water feature of the vicinity, the LVR. The isolated ephemeral streams and surface pools present on OU2 do not drain to the LVR directly, but appear to infiltrate and drain through an abandoned storm sewer system. The ponds constructed as part of the Carus Plant operations are sources for some infiltration into the slag deposits that underlie the ponds. The cooling water holding pond discharges into the LVR through a permitted NPDES discharge point near the south end of the Slag Pile.

The LVR flows along the eastern margin of the Site. This river supports a biological community as described in [Sections 7.0](#) and [8.0](#) under the Risk Assessment section of this report. The river was found to exhibit a considerable range of stages in response to precipitation events. River levels were as high as 8 to 10 ft above the normal pool, based on evidence of debris in trees along the banks, and undercutting erosion at the toe of the Slag Pile.

Water levels in wells installed along the bank of the LVR, which intercept WBZ1, rose in response to the higher river levels. This suggests that the rising river levels were a source of groundwater recharge, at least locally, during higher river stages.

6.3.5 Nature and Extent of Contamination

Table 6.3.5-1 summarizes the COIs that exceeded SVs across the Matthiessen and Hegeler Zinc Company Site. The COIs are listed by group and subdivided by geographic areas of OU1 and OU2. Within the groundwater matrix, the COIs are noted as being detected above the SVs in WBZ1 and WBZ2. Note that some COIs and matrices were not sampled in some areas. As recognized in the Consensus Document, exceedances of SVs do not in themselves indicate that an unacceptable risk to human health or the environment exists. Rather, an exceedance merely indicates the need for further evaluation in the risk assessment.

6.3.5.1 Soil/Solid Matrix

Metals represent the largest group of COIs and exhibit widest distribution and variability in concentration. See Table 6.3.5-1 for the list of metals exceeding SVs. Metal exceedances are present in shallow (0 to 2 ft bgs) and deep (> 2 ft bgs) soil samples, and distributed across the areas investigated in OU1 and OU2. Metals exceedances of SVs are also found in some of the sampled residential areas.

VOC exceedances are noted in a limited number of soil samples from the Plant Area of OU1, but were not noted elsewhere on-site. Pesticides were not noted in soil samples from OU1 or OU2. PCBs were noted in one sample from the Plant Area and also in samples from Investigative Areas 1, 2 and 3 in OU2. SVOCs were noted in samples from both OU1 and OU2. Asbestos was only noted in OU2.

6.3.5.2 Groundwater

As with the soil samples, metals were the most widely distributed contaminant group with exceedances of the GWSVs (Table 6.3.5-1). Exceedances of GWSVs were noted in both dissolved and total metals analyses in both WBZ1 and WBZ2.

A limited number of VOCs were detected at levels above the GWSVs in both OU1 and OU2. Exceedances of the VOC GWSVs were noted in both WBZ1 and WBZ2. In OU1, the wells exhibiting exceedances of the GWSVs were limited to the Plant Area.

SVOCs were also noted in groundwater samples from both OU1 and OU2, and were detected in both WBZ1 and WBZ2. As was the case with the VOC detections, the detections in OU1 were limited to the Plant Area.

No PCBs were detected above SVs in groundwater samples on the Site. Pesticides were detected above SVs in OU2 in both WBZ1 and WBZ2.

6.3.5.3 Surface Water and Sediments

Sediment sampling was limited to OU1. Sediment samples were collected from LVR sediments and in samples from the holding pond at the south end of the Slag Pile and from the west side of the Slag Pile Area near a seep originating on OU2. The Slag Pile Area sample concentrations exceeded SVs for metals, VOCs, SVOCs and PCBs. The sediments from the LVR contained concentrations that exceeded metals and SVOC SVs along the length sampled, and had a single SV exceedance for PCBs

There were limited surface water samples collected and submitted for laboratory analysis from the ephemeral streams and standing water pools of OU2. Those samples exhibited exceedances of the surface water SVs for a variety of metals and one pesticide. Surface water from OU1 consisted of numerous samples from the LVR. Those samples exhibited exceedances of surface water SVs for a variety of metals, but no other contaminant groups were detected above the SVs.

6.3.5.4 Building Materials and Debris

Within OU2, there were materials sampled as building materials and debris piles. These materials were present in Investigative Areas 1, 2, and 3. The materials sampled were found to exceed the SVs for a number of metals, SVOCs, PCBs, one pesticide, and asbestos. No such samples were taken on OU1 because its buildings are in current industrial use and it has no debris piles (the Slag Pile being considered in a separate category).

6.3.6 Contaminant Fate and Transport

The following sections summarize the potential migration of COIs in soil, groundwater, air, surface water and runoff, and sediments.

6.3.6.1 Potential Migration of COIs in Soil

The COIs investigated in soil included metals, VOCs, SVOCs, PCBs, and asbestos. Where exposed at the ground surface, these COIs may be attached to soil particles and migrate as fugitive dust. COIs attached to soil particles have a limited solubility and thus limited potential for vertical migration. However, COIs associated with soil particles at the surface may become eroded and migrate as suspended particles or dissolved in runoff. Particulates may be re-deposited or carried to the LVR and transported there or subsequently deposited in the sediment. Within the soil profile, the primary potential migration pathway is vertical transport of soluble COIs via rainfall infiltration to groundwater. The migration in groundwater is discussed below.

Asbestos fibers may become airborne and migrate. VOCs might have some potential to volatilize and migrate in air if present sufficiently near the surface. Mercury might also volatilize if it was present as elemental mercury, although this appears unlikely. The majority of the inorganic COIs are not volatile and not subject to transport as a vapor. The SVOCs and PCBs have sufficiently low volatility to minimize potential migration as a volatile compound.

6.3.6.2 Potential Migration in Groundwater

The COIs investigated in groundwater included metals, both total and dissolved, VOCs, SVOCs, and pesticides. These COIs were noted in both WBZ1 and WBZ2. The detection of these COIs in the dissolved fraction of the groundwater samples indicates that some portion of the matrix is soluble and thus is anticipated to migrate along groundwater flow paths, which generally trends to the east, toward

discharge at the LVR. The rate of this migration will be dependent on the hydraulic gradient, which appears to steepen near the LVR in both WBZ-1 (Figure 6.3.3-1) and WBZ-2 (Figure 6.3.3-2) and the hydraulic conductivity. WBZ1 tends to be more permeable allowing for more ease of migration. WBZ2 tends to be less permeable, therefore migration would be anticipated to be less than WBZ1. Other physio-chemical properties of the aquifer matrix material (e.g., mineralogy, particle size, organic carbon levels) and groundwater geochemistry (pH, ORP, major ions) will also influence the mobility of COIs. These physio-chemical properties under optimum conditions retard movement through processes that reduce their solubility (e.g., sorption, precipitation, change in speciation to less soluble form), but under some conditions may increase a COI's solubility and thus rate of migration.

6.3.6.3 Potential Migration in Air

Air monitoring and air sampling were conducted during sampling efforts in both OU1 and OU2. Additionally, asbestos monitoring was conducted on OU2. No detections were measured above the SVs. Based on the lack of detected COIs in air above SVs, the potential migration of COIs in concentrations of concern via air is not considered likely.

Asbestos fibers may become airborne and migrate. VOCs might have some potential to volatilize and migrate in air if present sufficiently near the surface. Mercury might also volatilize if it was present as elemental mercury, although this appears unlikely. Additionally, the potential for migration in air as fugitive dust does exist where fine grained soils are exposed to wind erosion. The COIs present in the soil samples would potentially be subject to airborne migration as dust.

6.3.6.4 Potential Migration in Surface Water and Runoff

Those COIs present in surface soil are potentially subject to erosion and subsequent migration in surface water and runoff. In OU2, some of the surface water is apparently flowing into the ASO, which eventually discharges into a small tributary to the LVR. Surface runoff and erosion on the surface of the Slag Pile are contributing sediment directly into the LVR.

COIs could be transported either as suspended particulates or as dissolved compounds, if sufficiently soluble. VOCs in surface water are likely to volatilize and be removed from the surface water. Due to their relatively low solubility, SVOCs and PCBs would likely be attached to particles and transported in suspension rather than as dissolved compounds. Metals were detected as both total and dissolved COIs, and are likely present both as suspended particles and dissolved COIs. Those COIs present in the surface

water as a result of erosion and subsequent migration will likely result in deposition to sediment or transport as either dissolved compounds or suspended particles.

6.3.6.5 Potential Migration in Sediments

Sediment sampling data was limited to OU1, either in the pond at the south end of the Slag Pile, at the seep from OU2 along the west edge of the Slag Pile, or in the LVR. No sediment was sampled on OU2. The COIs detected above SVs in sediments included metals, SVOCs, and PCBs. Metals are present in particles of slag within the sediment, and may either be transported as suspended particulates, or potentially leach into the surface water and migrate as dissolved constituents. Analysis of weathered (submerged) and unweathered (terrestrial) slag material ([Section 5.4.](#)) indicates that slag present in sediment has already been highly weathered as a result of being in contact with water. Thus, the potential for inorganic metals to be leached from these weathered materials into solution in surface water is limited compared to slag that has been recently transported to the LVR and has not undergone weathering. SVOCs and PCBs are sufficiently low solubility so as to be primarily transported adhering to particulates in suspension.

7.0 HUMAN HEALTH RISK ASSESSMENT

The following sections discuss the HHRA for the Matthiessen and Hegeler Zinc Company Site as it applies to OU1 ([Section 7.1](#)), OU2 ([Section 7.2](#)), and the overall Site ([Section 7.3](#)).

7.1 OU1 HUMAN HEALTH RISK ASSESSMENT

The HHRA conservatively characterizes risks to hypothetical human receptors potentially exposed to constituents detected in environmental media at OU1. The objectives of the HHRA were as follows:

- To investigate if site-related constituents detected in environmental media pose unacceptable risks to current and future human receptors under conditions at the time of the RI (unremediated conditions)
- To provide information to support decisions concerning the need for further evaluation or action based on current and reasonably anticipated future land use at OU1

Prior to conducting the risk assessments described above, Geosyntec and SulTRAC jointly prepared and submitted a technical approach Consensus Document describing the risk assessment methodology for the HHRAs (Appendix RA-1). For the purposes of conducting the HHRA, OU1 was subdivided into three exposure areas (EAs), primarily on the basis of current and reasonably anticipated (or hypothetical) future land use. These areas are: 1) Carus Plant Area; 2) Slag Pile Area; and 3) the LVR. The EAs are described below.

- **Carus Plant Area:** The Carus Plant Area is located in the southern portion of the Matthiessen and Hegeler Zinc Company Site. Carus has operated its plant on all or a portion of this area since approximately 1915, and it has been zoned “M-2” for heavy industrial use since 1958. Current operations include the production of specialty chemicals, including permanganate; future land use is anticipated to remain commercial/industrial. Limited areas of maintained grass or shrubs border the Carus Plant manufacturing buildings; however, ground cover primarily consists of pavement, gravel, and asphalt. Although the presence of pavement, gravel, and asphalt, precludes exposure to the underlying soils, all soil samples collected at the Carus Plant were evaluated in this risk assessment. The Carus Plant is bordered to the north by OU2, to the east by the Slag Pile, and to the south and west by residential areas or public parks.

- **Slag Pile Area:** The Slag Pile Area was defined based on slag delineation samples collected during the Phase I of the RI. The slag is composed of material generated from the primary zinc smelting process. It is unknown when the pile began to accumulate, but slag has not been added to the pile since the primary smelter ceased operation around 1961. Currently the Slag Pile Area is not used for any purpose; future land use is unknown, but likely to be limited due to the uncertain geotechnical load-bearing capacity of the Slag Pile. The easternmost portion of the Slag Pile consists of steep slopes extending to the LVR, which are mainly unvegetated on a year-round basis with the exception of lichen and moss growing along the low, moist areas adjacent to the river; US EPA also observed pioneer plants, including bladder-campion and an unidentified sedge (*Carex* spp.), encroaching on exposed slag. The remainder of the Slag Pile shows some habitat recovery as indicated by its ability to support limited vegetation. The Slag Pile is bordered to the north and northwest by OU2, to the west by the Carus Plant, to the southwest and south by private residences, and to the east by the LVR.
- **Little Vermilion River:** The LVR serves as the eastern boundary of OU1 and OU2. It generally runs from north to south toward its confluence with the Illinois River approximately one-mile south of the Matthiessen and Hegeler Zinc Company Site. The river in the vicinity of the Site follows a steep gradient with fast-moving runs and riffles commonly observed along with some pool habitats. Bottom substrates of the river consist of exposed bedrock, medium and large-sized rock, with gravel, cobble, and sand. Sand or gravel bars or islands within the river channel are common features, especially along the bend located at the northeast property boundary. The banks can become vertical in areas where the river channel narrows and the river deepens across the entire reach. Throughout its length, the river exhibits signs of wrested vegetation (water marks) from periodic and perhaps seasonal flood flows. Wildlife observations during the Site visit indicated that aquatic habitat in the LVR has the potential to support a diversity of aquatic life such as insects, mussels, and fish; and serves as a food source for mammals and birds of the area including habitat for wading birds. The near-bank riparian habitat along the LVR supports a plant community more adapted to periodic overbank flooding (floodplain) conditions, particularly in the low-lying area located directly north of the Highway 6 Bridge.

Consistent with standard risk assessment practice and US EPA guidance, the OU1 HHRA includes the following components: 1) data evaluation and selection of COPCs; 2) exposure assessment; 3) toxicity assessment; and 4) risk characterization. Each of these components is summarized from Appendix RA in the following subsections.

7.1.1 Data Evaluation and Selection of COPCs

Analytical data evaluated in the HHRA were collected during the CERCLA SSI (IEPA 1991), during the ISA (IEPA 1993b), during additional investigation in 1994 (Geosyntec 1996), and during Phases I (conducted by Geosyntec in 2007) and II (conducted by Geosyntec in 2009) of the comprehensive RI. All samples were analyzed for TAL metals, as they were the most likely chemicals present based on knowledge of historical Site uses and early investigations conducted at OU1. A subset of samples was analyzed for cyanide, PCBs, pesticides, SVOCs, and VOCs, as these chemicals had been measured in OU1 media to a more limited extent than the metals in the early investigations. The samples designated for cyanide, PCB, pesticide, SVOC, and VOC analysis were selected based on a stratified sampling design (no bias as to sampling depth or location).

Consistent with US EPA's approach for selecting chemical constituents for quantitative evaluation, maximum detected concentrations of constituents were compared to conservative screening levels to investigate COPCs. Medium-specific screening levels were selected as the most conservative values from US EPA's RSLs (updated November 2009, US EPA 2009h), IEPA's TACO and non-TACO objectives (IEPA 2008b), and federal and state water quality standards and criteria.

Summary statistics for detected constituents, HHSLs, COPCs, and the basis for COPC selection or exclusion are presented in Appendix RA-G1 in the following tables: Carus Plant surface soil - Table G1-2.1.1, Carus Plant subsurface soil – Table G1-2.1.2, Slag Pile surface soil – Table G1-2.2.1, Slag Pile subsurface soil – Table G1-2.2.2; LVR sediment – Table G1-2.3.1; LVR surface water – Table G1-2.3.2; LVR fish tissue (fillets) – Table G1-2.3.3; and OU1 Groundwater – Table G1-2.4.

7.1.2 Exposure Assessment

Current and future receptors that are reasonably anticipated or assumed to be exposed to site-related constituents in environmental media were investigated based on site-specific information. The receptors and exposure routes considered quantitatively in the OU1 HHRA are described below.

- **Current Commercial/Industrial Worker:** Current commercial/industrial workers were assumed to be exposed to surface soil at the Carus Plant via incidental ingestion, dermal contact, and inhalation of particulates and vapors in ambient air. Exposure to groundwater at the Carus Plant was assumed to occur via inhalation of vapors in ambient and indoor air. Groundwater vapor concentrations in ambient air were modeled using site-specific groundwater-to-ambient air volatilization factors (VF) developed using the ASTM Standard Guide for Risk-Based Corrective

Action (ASTM 2004). Groundwater vapor concentrations in indoor air were modeled using the Johnson and Ettinger (J&E) Model (1991). Risks from air concentrations were evaluated using standard Risk Assessment Guidance for Superfund (RAGS) methodology.

- **Future Commercial/Industrial Worker:** Future commercial/industrial workers are assumed to be exposed to surface soil and subsurface soil at the Carus Plant and Slag Pile via incidental ingestion, dermal contact, and inhalation of particulates and vapors in ambient air. Exposure to groundwater at the Carus Plant and Slag Pile was assumed to occur via ingestion and inhalation of vapors in ambient and indoor air. Groundwater vapor concentrations in ambient air were modeled using site-specific groundwater-to-ambient air VFs developed using the ASTM Standard Guide for Risk-Based Corrective Action (ASTM 2004). Groundwater vapor concentrations in indoor air were modeled using the J&E (1991) model. Risks from air concentrations were evaluated using standard RAGS methodology.
- **Current and Future Site-Specific Worker:** Current and future site-specific workers were assumed to be exposed to surface soil and subsurface soil at the Slag Pile via incidental ingestion, dermal contact, and inhalation of particulates and vapors in ambient air. Exposure to groundwater at the Slag Pile was assumed to occur via inhalation of vapors in ambient air. Groundwater vapor concentrations in ambient air were modeled using site-specific groundwater-to-ambient air VFs developed using the ASTM Standard Guide for Risk-Based Corrective Action (ASTM 2004).
- **Current and Future Utility Worker:** Current and future utility workers were assumed to be exposed to surface soil and subsurface soil at the Carus Plant and Slag Pile via incidental ingestion, dermal contact, and inhalation of particulates and vapors in ambient air. Exposure to groundwater at the Carus Plant and Slag Pile was assumed to occur via incidental ingestion, dermal contact, and inhalation of vapors while working in a trench. Note: the groundwater ingestion and dermal contact pathways are limited to shallow groundwater (less than 10 ft bgs) whereas the inhalation pathway considers groundwater of all depths. Concentrations of groundwater vapors in trench air were modeled using the Virginia Department of Environmental Quality (VDEQ 2008) trench model; risks from trench air concentrations were evaluated using standard RAGS methodology.
- **Future Construction Worker:** Future construction workers were assumed to be exposed to surface soil and subsurface soil at the Carus Plant and Slag Pile via incidental ingestion, dermal contact, and inhalation of particulates and vapors in ambient air. Exposure to groundwater at the Carus Plant and Slag Pile was assumed to occur via incidental ingestion, dermal contact, and

inhalation of vapors while working in a trench. Note: the groundwater ingestion and dermal contact pathways are limited to shallow groundwater (less than 10 ft bgs) whereas the inhalation pathway considers groundwater of all depths. Concentrations of groundwater vapors in trench air were modeled using the VDEQ (2008) trench model; risks from trench air concentrations were evaluated using standard RAGS methodology.

- **Current and Future Trespasser:** Current and future trespassers were assumed to be exposed to surface soil at the Slag Pile via incidental ingestion, dermal contact, and inhalation of particulates and vapors in ambient air. Exposure to groundwater at the Slag Pile was assumed to occur via inhalation of vapors in ambient air. Groundwater vapor concentrations in ambient air were modeled using site-specific groundwater-to-ambient air VFs developed using the ASTM Standard Guide for Risk-Based Corrective Action (ASTM 2004); risks from outdoor air concentrations were evaluated using standard RAGS methodology.
- **Future Recreationalist:** Future recreationalists were assumed to be exposed to surface soil and subsurface soil at the Slag Pile via incidental ingestion, dermal contact, and inhalation of particulates and vapors in ambient air. Exposure to groundwater at the Slag Pile was assumed to occur via inhalation of vapors in ambient air. Groundwater vapor concentrations in ambient air were modeled using site-specific groundwater-to-ambient air VFs developed using the ASTM Standard Guide for Risk-Based Corrective Action (ASTM 2004); risks from outdoor air concentrations were evaluated using standard RAGS methodology.
- **Hypothetical Future Resident:** Hypothetical future residents were assumed to be exposed to surface and subsurface soil at the Carus Plant via incidental ingestion, dermal contact, inhalation of particulates and vapors in ambient air, and ingestion of homegrown produce. Hypothetical future residents were assumed to be exposed to groundwater at the Carus Plant via ingestion, dermal contact, inhalation of vapors in outdoor air, and inhalation of vapors in indoor air as a result of household use and vapor intrusion. Groundwater vapor concentrations in ambient air were modeled using site-specific groundwater-to-ambient air VFs developed using the ASTM Standard Guide for Risk-Based Corrective Action (ASTM 2004). Vapor concentrations in indoor air (from vapor intrusion) were modeled from groundwater concentrations using the J&E Model (1991). Risks from air concentrations were evaluated using standard RAGS methodology.
- **Current and Future LVR Angler:** Current and future anglers were assumed to be exposed to sediment and surface water in the LVR via incidental ingestion and dermal contact.
- **Current and Future Fish Consumer:** Current and future fish consumers were assumed to ingest fish tissue (fillets) from the LVR.

Receptor-specific intakes for each exposure route were calculated under both reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions using the exposure point concentrations (EPCs) presented in the RAGS Part D 3 Series tables, and the equations and exposure parameter values presented in the RAGS Part D 4 Series tables (included as part of Appendix RA-G1).

Medium-specific EPCs were calculated using the methodology presented in Appendix RA-3. The OUI COPC datasets are presented in Appendix RA-G3. Generally, for the RME and CTE scenarios, EPCs were calculated as the 95 percent upper confidence limit (UCL) on the mean of each EA- and medium-specific dataset using US EPA's ProUCL Version 4.00.04 statistical software package (US EPA 2009b). The EPC was selected as the 95 percent UCL of the statistical method result recommended by ProUCL. Statistical treatment was not conducted for constituents with less than eight detected results. In this circumstance, the maximum detected concentration was used as the EPC. Maximum detected concentrations were also used as the EPCs to evaluate utility worker and construction worker exposure scenarios and all groundwater exposure scenarios. Modeling was used to generate medium-specific EPCs for media not sampled directly. Specifically, modeling was used to estimate EPCs for blood lead, trench air, indoor air, outdoor air (from groundwater), and homegrown produce.

7.1.3 Toxicity Assessment

The risk assessment used the default toxicity values presented in the US EPA RSL tables (US EPA 2009h). The default values were obtained from the following sources in the order presented below:

- Integrated Risk Information System (IRIS) on-line database (US EPA 2010c)
- Provisional Peer Reviewed Toxicity Values (PPRTVs) derived by US EPA's Superfund Health Risk Technical Support Center for the US EPA Superfund Program
- ATSDR minimal risk levels (MRL) (ATSDR 2009)
- The California Environmental Protection Agency (CalEPA)/Office of Environmental Health Hazard Assessment's toxicity values (CalEPA 2003)
- Screening toxicity values in appendices to certain PPRTV assessments
- The US EPA Superfund Program's Health Effects Assessment Summary Tables (HEAST) (US EPA 1997b)

Toxicity values used in the HHRA are presented in the RAGS Part D 5 and 6 Series tables for non-carcinogens and carcinogens, respectively (included as part of Appendix RA-G1).

US EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model and Adult Lead Model (ALM) were used to assess potential risks associated with exposure to lead for residents and non-residents, respectively (US EPA 2003a, 2009c, 2009d, and 2009e). Specifically, potential risks from lead were characterized by comparing concentrations of lead in soil to a receptor-specific PRG. The US EPA default RSLs of 400 and 800 mg/kg were selected as the PRGs for residents and adult commercial/industrial workers (US EPA 2009h), respectively. Receptor-specific lead PRGs for utility workers, construction workers, trespassers, and recreationalists were developed under both RME and CTE conditions using US EPA's ALM (US EPA 2009d) and receptor-specific exposure parameters as described in Appendix RA-4. The table below summarizes the receptor-specific soil lead PRGs. For construction and utility worker exposure scenarios, the maximum detected concentration was used as the EPC for lead. For all other exposure scenarios, the average concentration was used as the EPC for lead.

Receptor	Soil Lead PRG (mg/kg)	
	RME Conditions	CTE Conditions
Child and Adult Resident	400	400
Adult Commercial/Industrial Worker	800	800
Adult Utility Worker	12,262	24,524
Adult Construction Worker	941	2,038
Adult Site-Specific Worker	8,175	24,524
Adolescent Trespasser	6,563	13,438
Adult Trespasser	6,563	13,438
Child Recreationalist	896	1,552
Adolescent Recreationalist	6,563	13,438
Adult Recreationalist	6,563	13,438

7.1.4 Risk Characterization

In the risk characterization, the exposure estimates are integrated with toxicity factors to estimate potential carcinogenic and non-carcinogenic health risks. As detailed in Appendix RA-G, the risk characterization considered the relative bioavailability (RBA) of metals, specifically arsenic, using a tiered approach, which began with an assumption of 100 percent bioavailability. In the majority of

receptor-exposure scenarios arsenic was identified as a risk driver (Appendix RA-G6). Considered as a whole, the Tier 1 results indicated that the OU1 HHRA should proceed to the next tier—use of a default arsenic-specific RBA for arsenic. The risk characterization results for the Carus Plant, Slag Pile, and LVR presented herein are based on an arsenic RBA of 0.8, which has also been incorporated into IEPA's TACO regulations and is consistent with the arsenic RBA value used at other Region 5 sites.

The RAGS D Table 7 Series (Appendix RA-G1) list the EPCs, average daily dose (ADD) and average daily exposure, toxicity values, and calculated cancer risks and non-cancer hazards. Constituents of concern (COCs) are those COPCs with either an individual: 1) Excess Lifetime Cancer Risk (ELCR) greater than 1.0×10^{-6} ; or 2) non-cancer HQ greater than 0.1, which contributes to a target organ HI greater than 1.0. COCs are retained for further evaluation in the FS.

7.1.4.1 Summary of Risks and Hazards at the Carus Plant Area

At the Carus Plant EA, under RME and CTE assumptions and applying US EPA HHRA guidance, cancer risks were within US EPA's acceptable risk range for current commercial/industrial workers, current and future utility workers, and future construction workers. As discussed more fully above, the potential RME cancer risk exceeded the acceptable risk range for future commercial/industrial workers (due to assumed groundwater consumption); however, potential CTE cancer risks were within US EPA's acceptable risk range for future commercial/industrial workers. Aside from groundwater consumption, arsenic, hexavalent chromium (calculated from total chromium), Aroclor 1245, Aroclor 1260, and benzo(a)pyrene were the primary cancer risk drivers in soil. However, it should be noted that risks from Aroclor 1254, Aroclor 1260, and benzo(a)pyrene were based on maximum detected concentrations due to their infrequent detection at the Carus Plant. Cancer risks to current and future commercial/industrial workers are also likely biased high due to the inclusion of samples currently under pavement in the risk assessment dataset.

Non-cancer RME and CTE HIs exceeded 1 for all receptor-exposure scenarios evaluated at the Carus Plant. Aside from the groundwater consumption scenarios, manganese and, to a lesser extent, mercury in soil were the primary non-cancer risk drivers. However, it should be noted that risks from manganese are driven by a single sample collected in the 1990s in surficial soil (see below). Also note that total mercury was simultaneously evaluated as inorganic and elemental mercury, thus, overestimating risks from mercury. Based on the assumption that all mercury in groundwater was volatile (i.e., present as elemental mercury), inhalation of mercury vapors from groundwater in trench air also contributed to overall non-cancer risks to utility and construction workers. Non-cancer risks to current commercial/industrial

workers are also likely biased high due to the inclusion of samples currently under pavement in the risk assessment dataset.

Cancer risks greater than 1×10^{-6} and non-cancer HIs greater than 1 were also calculated for the hypothetical residential RME and CTE soil and groundwater exposure scenarios at the Carus Plant.

To evaluate potential risks from lead, measured soil concentrations were compared to receptor-specific PRGs; for commercial/industrial and residential scenarios, average lead concentrations were used as the EPCs, and for utility and construction worker scenarios, maximum lead concentrations were used as the EPCs. The average lead concentration in surface soil (but not subsurface soil) exceeded the residential RME and CTE PRGs and the maximum lead concentration in subsurface soil exceeded the construction worker RME PRG, indicating there is a potential for adverse effects from exposure to lead in soil for these receptors. In addition, the maximum groundwater concentration exceeded the Federal MCL; thus, potable use of groundwater, if it was allowed, has the potential to result in adverse effects to relevant receptors. Receptor-specific lead PRGs were not exceeded for any other exposure scenario at the Carus Plant Area.

Several factors introduced uncertainties into the risk estimates for the Carus Plant. Non-cancer risks were primarily driven by exposure to manganese in soil; the manganese EPC (and risks) was heavily biased by a single sample (SSI-X102) collected during the CERCLA SSI (IEPA 1991). Reported manganese concentrations at SSI-X102 were 118,000 mg/kg, whereas the next greatest concentration at the Carus Plant was 10,500 mg/kg – over an order of magnitude less. Given the age of the data, there is uncertainty associated with the analytical results. The level of uncertainty is increased by the fact that the analytical results for other TAL metals at SSI-X102 are inconsistent with soil data collected at other locations at the Carus Plant. For example, arsenic, lead, and zinc are reported as non-detect at SSI-X102, but, these constituents were detected at all other locations at the Carus Plant Area. Thus, SSI-X102 does not appear to be representative of OU1 soil conditions. It should also be noted that subsequent to the SSI, this area of the site was paved, thus precluding direct contact exposure. Furthermore, assumptions regarding commercial/industrial worker exposure likely biased the risk estimates high. The Carus Plant Area is an active industrial plant, which produces various chemicals, including potassium permanganate. It is likely that the material sampled as site soil in sample SSI-X102 contained a significant amount of processing ore (approximately 50 percent manganese) utilized in the normal operations of the Carus facility. Because this is an industrial facility, it is regulated by the OSHA and, as such, facility workers must be provided with safety information (including chemical safety information) and receive regular training. However, the exposure estimates used in the model do not account for OSHA regulations or industrial-type training;

rather, they are based on a commercial worker who is not subject to OSHA regulations. Moreover, the exposure estimates do not include an 'exposure time'(ET) variable, but assume an all-day exposure. Even if the Carus Plant was unpaved so that direct contact with soils was a complete pathway most commercial/industrial workers would likely be exposed to soil outdoors for only a small portion of the day while walking between buildings, to parking lots, or on security patrols.

Risks to current utility workers were also likely biased high due to the use of maximum detected concentrations for EPCs; as a result, these risks estimates do not represent exposure-area wide risks or location-specific risks (i.e., all maxima are not co-located). It should also be noted that in soil, only manganese resulted in an individual HQ greater than 0.1 and that the result was driven by the SSI (IEPA 1991) manganese sample results at SSI-X102. As discussed above, this sample does not appear to be representative of OU1 soil conditions. As noted above, this location was paved subsequent to the SSI and utilities are not known to be present in this location. Mercury in groundwater also contributed to overall non-cancer risks to utility workers; however, it should be noted that because mercury speciation data was not available, inhalation risks from mercury were calculated under the assumption that 100 percent of on-site mercury was elemental mercury, which, likely overestimates risks from mercury by an order of magnitude or more.

Other primary sources of uncertainty for risks and hazards calculated for receptors at the Carus Plant include: 1) the inclusion of all available data, including sample SSI-X102, despite the fact that many soils which were accessible in the 1990s have since been paved; 2) the assumption that groundwater will be used for drinking water, when such use is prohibited; and 3) the use of maximum detected concentrations for infrequently detected compounds (e.g., PCBs). These uncertainties are further evaluated either qualitatively or quantitatively in Section 2.6 of Appendix RA.

7.1.4.2 Summary of Risks and Hazards at the Slag Pile Area

Under RME and CTE assumptions and applying US EPA HHRA guidance, cancer risks were within or below US EPA's acceptable risk range for current and future site-specific workers, current and future utility workers, future construction workers, current and future trespassers, and future recreationalists. Potential RME and CTE cancer risk exceeded the acceptable risk range for future commercial/ industrial workers (due to assumed groundwater consumption). When soil exposure scenarios predicted cancer risks within US EPA's acceptable risk range, arsenic was the primary risk driver. Hexachlorobenzene and benzo(a)pyrene also contributed cancer risks greater than 1×10^{-6} for certain scenarios; however, these

risk estimates were based on maximum detected concentrations due to the infrequent detection of these constituents at the Slag Pile Area.

RME and CTE HIs were less than one for current and future site-specific workers, current and future trespassers, and future recreationalists. The HI for current and future utility workers exceeded one under RME assumptions due to the presence of various metals in soil, but was less than one under CTE assumptions. Even though future redevelopment of the Slag Pile Area is unlikely, exposure scenarios for future commercial/industrial workers and future construction workers were evaluated; these scenarios resulted in non-cancer RME and CTE HIs greater than 1. For future commercial/industrial workers, non-cancer risks were primarily driven by the assumed consumption of groundwater; however, soil RME and CTE HIs also exceeded 1. Non-cancer risks to future construction workers were driven by the presence of various metals in soil and, to a lesser extent, the inhalation of (assumed elemental) mercury in trench air. When soil exposures exceeded 1, manganese was the primary non-cancer risk driver at the Slag Pile.

There is a potential for adverse effects from exposure to lead in soil under RME and CTE scenarios for future commercial/industrial workers, current and future utility workers, future construction workers, and future child recreationalists. The maximum groundwater concentration exceeded the Federal MCL; thus, potable use of groundwater, if allowed over the current prohibition, would have the potential to result in adverse effects from lead. Receptor-specific lead PRGs were not exceeded for any other exposure scenario at the Slag Pile Area.

Other primary sources of uncertainty for risks and hazards calculated for receptors at the Slag Pile include: 1) the use of maximum detected concentrations for utility and construction worker exposure scenarios; 2) the assumption that groundwater will be used for drinking water, even though it is prohibited; and 3) the use of maximum detected concentrations for infrequently detected compounds (e.g., PAHs). These uncertainties are further evaluated either qualitatively or quantitatively in Section 2.6 of Appendix RA.

7.1.4.3 Summary of Risks and Hazards at the LVR

Under RME assumptions and applying US EPA HHRA guidance, cancer risks were below US EPA's acceptable risk range (for adolescent anglers, child fish consumers, and adolescent fish consumers) or within that range (for adult anglers and adult fish consumers). Under CTE assumptions, cancer risks were below 1×10^{-6} for all receptor-exposure scenarios evaluated. The calculated cancer risks were driven by arsenic. Concentrations of total arsenic in fillets (n=2) collected from LVR reaches adjacent to the Site

were 0.67 and 0.13 mg/kg. No fillets were available from the upstream LVR reach. However, whole body concentrations of arsenic in fish captured upstream were actually somewhat higher, but generally comparable to the concentrations in fish captured adjacent to the Site. Whole body concentrations for fish captured adjacent to the Site ranged from 0.17 to 0.57 mg/kg with an average concentration of 0.28 mg/kg, whereas in the upstream reference area samples, the whole body concentrations (n=2) were 0.29 and 0.53 mg/kg (0.41 mg/kg average).

Non-cancer RME HIs were less than 1 for adolescent and adult anglers, and adolescent and adult fish consumers. The non-cancer RME HI exceeded 1 for child fish consumers. Mercury, assumed to be methyl mercury, was the primary contributor to the calculated non-cancer risk; however, mercury concentrations in the fillets collected from the LVR were within the range shown in the US EPA's National Study of Chemical Residues in Lake Fish Tissue (US EPA 2009f). No unacceptable risks were shown for the CTE scenario.

7.1.4.4 Localized Impact Evaluation

As described in Attachment 5 of the Consensus Document, detected concentrations in soil (0 to 10 ft bgs) were also compared to the Illinois TACO and non-TACO values based on a construction worker exposure scenario to investigate constituents that may have localized areas of elevated concentrations. Tables G2-4.1 and G2-4.2 of Appendix RA-G2 present this comparison. At the Carus Plant, concentrations of lead, manganese, Aroclor 1254, and Aroclor 1260 exceeded the construction worker SVs at one or more locations. Soil concentrations at the Carus Plant were less than 3 times their respective construction worker SVs, with the exception of manganese at sample SSI-X102 (IEPA 1991). See [Section 7.1.4.1](#) for a discussion of the uncertainties associated with sample SSI-X102. At the Slag Pile, concentrations of arsenic, lead, manganese, zinc, and hexachlorobenzene exceeded the construction worker SVs at one or more locations. Importantly, these screening levels are not remediation levels; risk-based remedial actions to address potential construction worker risks should be based on the quantitative risk estimates discussed in the preceding sections. However, localized areas of elevated concentrations of these COPCs, which were investigated through this screening process, will be considered in conjunction with the EA-wide risk estimates during the risk management phase.

7.1.5 Uncertainties

The OU1 HHRA has a variety of sources of uncertainty which are specifically detailed in Section 2.6.2 of Appendix RA. In summary, the general sources of uncertainty are associated with the CSM, analytical

data, exposure estimates, toxicity factors, and background contributions. OU1-specific sources of uncertainty include: use of all available analytical data, including data collected in the 1990s (some of which is from sample locations that have subsequently been paved); EPCs for infrequently detected compounds (i.e., maximums) and datasets with high variability; current commercial/industrial exposure assumptions; construction and utility worker exposure assumptions; evaluation of indoor air exposures; chemical-specific assumptions regarding arsenic, chromium, and mercury in environmental media; and contribution of background risks to overall site-related risks.

7.1.6 OU1 HHRA Summary and Conclusions

The following sections provide summaries and conclusions of the HHRA for OU1 groundwater, the Carus Plant Area, Slag Pile Area, and LVR.

7.1.6.1 Groundwater

There are no groundwater supply wells at OU1 and groundwater is not used for potable or industrial uses, including irrigation. An ordinance of the City of LaSalle in conjunction with a Memorandum of Understanding (MOU) between the City and IEPA legally prohibits the drilling of water wells at OU1 for the purpose of obtaining a water supply. However, hypothetical future pathways assuming groundwater consumption were evaluated to provide risk managers with quantitative risk calculations to support the evaluation of risk management measures regarding groundwater use at OU1. If this pathway was complete, applying US EPA HHRA guidance, the calculated cancer and non-cancer risk estimates from groundwater consumption (and thus total receptor risks) would exceed US EPA's acceptable risk limits (i.e., cancer risks greater than 1×10^{-4} and non-cancer HIs greater than 1) for future commercial/industrial workers at the Carus Plant and Slag Pile, and hypothetical future residents at the Carus Plant. In the case of future commercial/ industrial workers, the unacceptable cancer risk (i.e., cancer risk greater than 1×10^{-4}) is entirely attributable to the assumption of future groundwater consumption; if that assumption is eliminated, consistent with existing law, then the calculated cancer risk estimate for future commercial/industrial workers would be within US EPA's acceptable risk range (i.e., between 1×10^{-6} and 1×10^{-4}). (However, as described below, total receptor HIs for future commercial/industrial workers would still exceed 1.) For the assumed residential scenario, calculated cancer and non-cancer risks exceed the acceptable risk range based on groundwater consumption as well as exposure to soil and homegrown produce. In addition, the maximum groundwater concentration of lead exceeded the Federal MCL; thus, potable use of groundwater, if it was allowed, has the potential to result in adverse effects to relevant receptors.

7.1.6.2 Carus Plant Area

Under current conditions, there is no residential use of the Carus Plant Area and none is reasonably anticipated given the long industrial use of the property, zoning, and other factors making residential redevelopment of the property unlikely. As with groundwater use, hypothetical future residential land use of the Carus Plant was assumed to provide information for the evaluation of risk management decisions during the FS. Applying the US EPA HHRA methodology, residential use scenarios would predict RME and CTE cancer risks above US EPA's acceptable risk limits and also RME and CTE non-cancer HIs greater than 1 based on exposure to soils and home grown produce. As noted above, unacceptable cancer and non-cancer risks estimates were also calculated for the hypothetical residential RME and CTE groundwater exposure scenarios at the Carus Plant Area.

At the Carus Plant EA, under RME and CTE assumptions and applying US EPA HHRA guidance, cancer risks were within US EPA's acceptable risk range for current commercial/industrial workers, current and future utility workers, and future construction workers. As discussed more fully above, the potential RME cancer risk exceeded the acceptable risk range for future commercial/industrial workers (due to assumed groundwater consumption); however, potential CTE cancer risks were within US EPA's acceptable risk range for future commercial/industrial workers. Aside from groundwater consumption, arsenic, hexavalent chromium (calculated from total chromium), Aroclor 1245, Aroclor 1260, and benzo(a)pyrene were the primary cancer risk drivers in soil. However, it should be noted that risks from Aroclor 1254, Aroclor 1260, and benzo(a)pyrene were calculated based on maximum detected concentrations due to their infrequent detection at the Carus Plant. Cancer risks to current and future commercial/industrial workers are also likely biased high due to the inclusion of samples currently under pavement in the risk assessment dataset.

Non-cancer RME and CTE HIs exceeded 1 for all receptor-exposure scenarios evaluated at the Carus Plant. Aside from the groundwater consumption scenarios, manganese and, to a lesser extent, mercury in soil were the primary non-cancer risk drivers. However, it should be noted that risks from manganese are driven by a single sample collected in the 1990s in surficial soil. Also note, total mercury was simultaneously evaluated as inorganic and elemental mercury, thus, overestimating risks from mercury. Based on the assumption that all mercury in groundwater was volatile (i.e., present as elemental mercury), inhalation of mercury vapors from groundwater in trench air also contributed to overall non-cancer risks to utility and construction workers. Non-cancer risks to current commercial/industrial workers are also likely biased high due to the inclusion of samples currently under pavement in the risk assessment dataset.

Potential risks from exposure to lead were characterized by comparing the lead EPC in soil to a receptor-specific PRG. For construction and utility worker exposure scenarios, the maximum detected concentration was used as the EPC for lead. For all other exposure scenarios, the average concentration was used as the EPC for lead. There is a potential for adverse effects from exposure to lead in soil under an RME scenario for hypothetical future residents (surface soil only) and construction workers (subsurface soil); for hypothetical future residents there is also a potential for adverse effects from exposure to lead under a CTE scenario. As discussed above, maximum concentrations of lead in groundwater exceeded the Federal MCL, which could pose a risk if future groundwater consumption is assumed. Receptor-specific lead PRGs were not exceeded for any other exposure scenario at the Carus Plant.

7.1.6.3 Slag Pile Area

At the Slag Pile EA, under RME assumptions and applying US EPA HHRA guidance, cancer risks were within US EPA's acceptable risk range for current and future site-specific workers, current and future utility workers, future construction workers, current and future trespassers, and future recreationalists. Potential RME cancer risk exceeded the acceptable risk range for future commercial/industrial workers (due to assumed groundwater consumption). Under CTE assumptions and applying US EPA HHRA guidance, cancer risks were below US EPA's acceptable risk range for future construction workers, current and future trespassers, and future adolescent and adult recreationalists, and within US EPA's acceptable risk range for current and future site-specific workers, current and future utility workers, and future child recreationalists. Potential CTE cancer risks exceeded the acceptable risk range for the future commercial/industrial worker scenario (driven by assumed groundwater consumption). When soil exposure scenarios predicted cancer risks within US EPA's acceptable risk range, arsenic was the primary risk driver. Hexachlorobenzene and benzo(a)pyrene also contributed cancer risks greater than 1×10^{-6} for certain scenarios; however, these risk estimates were based on maximum detected concentrations due to the infrequent detection of these constituents at the Slag Pile Area. Assumptions regarding arsenic bioavailability in slag may also have overestimated potential arsenic risks from soil exposure.

RME and CTE HIs were less than 1 for current and future site-specific workers, current and future trespassers, and future recreationalists. The HI for current and future utility workers exceeded 1 under RME assumptions due to the presence of various metals in soil, but was less than 1 under CTE assumptions. Even though future redevelopment of the Slag Pile Area is unlikely, exposure scenarios for future commercial/industrial workers and future construction workers were evaluated; these scenarios resulted in non-cancer RME and CTE HIs greater than 1. For future commercial/industrial workers, non-

cancer risks were primarily driven by the assumed consumption of groundwater; however, soil RME and CTE HIs also exceeded 1. Non-cancer risks to future construction workers were driven by the presence of various metals in soil and, to a lesser extent, the inhalation of (assumed elemental) mercury in trench air. When soil exposures exceeded 1, manganese was the primary non-cancer risk driver at the Slag Pile Area.

Potential risks from exposure to lead were characterized by comparing the lead EPC in soil to a receptor-specific PRG. For construction and utility worker exposure scenarios, the maximum detected concentration was used as the EPC for lead. For all other exposure scenarios, the average lead concentration was used as the EPC for lead. There is a potential for adverse effects from exposure to lead in soil under RME and CTE scenarios for future commercial/industrial workers, current and future utility workers, future construction workers, and future child recreationalists. The maximum concentrations of lead in groundwater exceeded the Federal MCL, which could pose a risk if future groundwater consumption is assumed. Receptor-specific lead PRGs were not exceeded for any other exposure scenario at the Slag Pile.

7.1.6.4 LVR

At the LVR EA, under RME assumptions and applying US EPA HHRA guidance, cancer risks were below US EPA's acceptable risk range (for adolescent anglers, child fish consumers, and adolescent fish consumers) or within that range (for adult anglers and adult fish consumers). Under CTE assumptions, cancer risks were below 1×10^{-6} for all receptor-exposure scenarios evaluated. When predicted cancer risks were within US EPA's acceptable risk range, arsenic was the primary risk driver.

Non-cancer RME HIs were less than 1 for adolescent and adult anglers, and adolescent and adult fish consumers. The non-cancer HI exceeded 1 for child fish consumers. Mercury, assumed to be methyl mercury, was the primary contributor to the calculated non-cancer risk; however, mercury concentrations in the fillets collected from the LVR were within the range shown in the US EPA's National Study of Chemical Residues in Lake Fish Tissue (US EPA 2009f). No unacceptable non-cancer risks were shown for the CTE scenario.

7.1.7 Overall OU1 HHRA Conclusions

In summary, applying US EPA's HHRA guidance and RME assumptions, the OU1 HHRA shows that calculated cancer risks for current and reasonably anticipated future land use scenarios are within or below US EPA's acceptable risk range. Applying the same guidance, the OU1 HHRA calculated HIs

greater than 1 for a number of exposure scenarios and assumptions, primarily due to the presence of metals in soil or slag, and in some cases due to the assumed presence of certain species of metals (i.e., elemental mercury and hexavalent chromium) in soil or slag.

When hypothetical future land uses allowing for groundwater consumption, which is contrary to current law, and/or residential use of the Carus Plant Area, which is not reasonably anticipated, were assumed, and US EPA HHRA guidance was applied, the OU1 HHRA resulted in calculated cancer and non-cancer risk estimates that exceed US EPA's acceptable limits.

7.2 OU2 HUMAN HEALTH RISK ASSESSMENT

The following sections discuss the OU2 HHRA objectives, EAs, approach, results, uncertainties, and a summary of overall HHRA conclusions for OU2.

7.2.1 Objectives

The OU2 HHRA evaluates current and future human health risks and hazards associated with exposure to site-related constituents at OU2. The objectives of the HHRA were as follows:

- To evaluate if site-related constituents detected in environmental media pose unacceptable risks to current and future human receptors under baseline (unremediated) conditions;
- To provide information to support decisions concerning the need for further evaluation or action based on current and reasonably anticipated future land use at OU2.

7.2.2 OU2 Exposure Areas

To conduct the HHRA, OU2 was subdivided into seven EAs primarily based on current and reasonably anticipated future land use: Main Plant Area (EA1), Wooded Area – North (EA2), Wooded Area – Northeast (EA3), Building 100 Hot Spot (EA4), Rolling Mill Area (EA5), off-site residential area (EA6), and off-site mixed-use area (EA7). Figure RA-S2-1 in Appendix RA shows these OU2 HHRA EAs. The EAs are defined as summarized below.

- EA1, Main Plant Area: The Main Plant Area occupies approximately 65 acres in the central and west-central portions of the Matthiessen and Hegeler Zinc Company Site. The Main Plant Area has been inactive since 1978, and trespassing has been observed in this area. Future land use is anticipated to be commercial/industrial or recreational. Most of the building and operational structures in the Main Plant Area are in significant disrepair. The ground surface consists of

exposed soil, slag, and sinter. Piles of these same materials as well as building materials also are present. Asbestos tiles, insulation, and fibers are present on the ground at various locations throughout the Main Plant Area.

- EA2, Wooded Area – North: The Wooded Area – North occupies about 15 acres in the northwest portion of the Matthiessen and Hegeler Zinc Company Site. No historical manufacturing operations took place in this area. The Wooded Area – North is currently inactive, and trespassing has been observed in this area. Future land uses are anticipated to be residential, commercial/industrial, and recreational. Trees are present over much of this area, especially in the northern two-thirds of the area. The ground surface consists of grasses with areas of exposed soil. Sinter and slag (sometimes as piles) are also present, especially in the southern portion of this area.
- EA3, Wooded Area – Northeast: The Wooded Area – Northeast occupies about 30 acres in the northeast portion of the Matthiessen and Hegeler Zinc Company Site. No historical manufacturing activities took place in this area. The area is heavily wooded except for some areas of exposed soil in the west-central portion. Trespassing has been observed in this area. Future land use is anticipated to be recreational.
- EA4, Building 100 Hot Spot: The Building 100 Hot Spot occupies about 0.75 acre in the west-central portion of the Matthiessen and Hegeler Zinc Company Site. The ground surface consists of exposed soil, slag, and sinter. Several piles of these same materials also are present. Trespassing has been observed throughout the Main Plant Area, which surrounds the Building 100 Hot Spot. Therefore, trespassing is assumed to have occurred or could occur at the Building 100 Hot Spot. Future land use is anticipated to be commercial/industrial or recreational.
- EA5, Rolling Mill Area: The Rolling Mill Area consists of approximately 9 acres immediately north of OU1 (the Carus Plant) and in the mid-southwest portion of the Matthiessen and Hegeler Zinc Company Site. The Rolling Mill stored backerboard in Summer and Fall 2007 and a tracker trailer flatbed in Fall 2008. However, the Rolling Mill currently is not used for any regular commercial/industrial operations. Future land use is anticipated to be commercial/industrial or recreational. The ground surface in this area is largely composed of asphalt and concrete, with areas of grass.
- EA6, Off-site Residential Area: The Off-site Residential Area consists of about 1,600 acres northwest, west, southwest, and south of the Matthiessen and Hegeler Zinc Company Site. This area contains numerous private residences, some commercial operations, and a variety of public parks. Trees are present throughout this area, and most of the ground surface is covered by lawns

and asphalt or concrete roads. Exposures, risks, and hazards were evaluated separately for 185 individual properties within EA6.

- EA7, Off-site Mixed-Use Area: The Off-site Mixed-Use Area consists of approximately 30 acres east of the LVR. The area runs along the east bank of the LVR from the southernmost end of the Matthiessen and Hegeler Zinc Company Site to the north end of the Rockwell/Oakwood Cemetery and has a west-east width of about 500 ft. The entire area is heavily wooded and consists of a narrow, relatively flat area immediately adjacent to the river, with the remaining width consisting of a steep incline rising to the east. The Off-site Mixed-Use Area is currently thought to be used for limited recreational activity (such as fishing). Future land use is also anticipated to be limited recreational.

7.2.3 HHRA Approach

Before conducting the risk assessments, Geosyntec and SulTRAC jointly prepared and submitted a technical approach Consensus Document dated May 14, 2009, describing the risk assessment methodology for the SLERAs, BERAs, and HHRA (Appendix RA-1). Agency comments regarding the risk assessment approach (including screening levels and statistical methods) have been addressed as applicable in the OU2 HHRA.

Consistent with standard risk assessment practice and US EPA guidance (US EPA 1989), the OU2 HHRA includes the following components: 1) data evaluation and selection of COPCs; 2) exposure assessment; 3) toxicity assessment; and 4) risk characterization.

Medium-specific data sets used to prepare the OU2 HHRA consisted of results for soil (surface [0 to 2 ft bgs] and subsurface [0 to 10 ft bgs]), groundwater, surface water, air, and vegetation samples collected as part of Phases I and II of the OU2 RI. COPCs were selected following US EPA guidance (primarily US EPA's RAGS (US EPA 1989) based on: 1) screening of maximum detected concentrations against medium-specific screening levels selected as the most conservative values from US EPA's RSLs, IEPA's TACO and non-TACO objectives, and federal and state water quality standards and criteria; 2) comparison to site-specific background concentrations (presented in Appendix RA-2); and 3) elimination of essential nutrients.

As defined in RAGS Part A (US EPA 1989), the four elements necessary to form a complete exposure pathway include:

- A source or release from a source,

- A mechanism of release and transport,
- A point of contact between the potential receptor contact, and
- An exposure route.

If any one of the four elements is missing, the exposure pathway is incomplete. The HHRA evaluates complete exposure pathways only. These four elements were evaluated as part of an OU2-specific CSM. The OU-specific CSM shows potentially complete exposure pathways by which receptors could contact site-related constituents. These exposure pathways were used throughout the investigation and remediation processes to: 1) provide a framework for addressing potential risks; 2) evaluate the need for additional data collection activities; and 3) evaluate health risks and the need for corrective measures. Figure RA-S2-2 in Appendix RA presents the OU2 CSM.

Soil is the major contaminated medium investigated at OU2. Soil contamination primarily resulted from historical coal mining and smelting operations. Other operations and events at OU2 also have impacted soil and surface water at OU2, including off-site portions (EAs 6 and 7). These operations and events include Rolling Mill operations and events; sulfuric acid manufacturing; an ammonium sulfate fertilizer plant; incidental releases; and spills, leaks, and airborne transport of particulates during operations. Constituents in soil also may have leached to groundwater beneath OU2. As a result, receptors at OU2 could be exposed to site-related constituents in surface soil, subsurface soil, groundwater, surface water, and produce grown in contaminated soil.

The receptors and exposure routes considered either quantitatively or qualitatively in the OU2 HHRA include the following:

- **Future Commercial/Industrial Worker:** Incidental ingestion of, dermal contact with, and inhalation of particulates and vapors from surface and subsurface soil and groundwater (ingestion and inhalation only) at all five on-site EAs at OU2.
- **Current and Future Utility Worker:** 1) Incidental ingestion of, dermal contact with, and inhalation of particulates and vapors from surface and subsurface soil at the Off-site Residential Area (EA6) and all five on-site EAs at OU2; and 2) incidental ingestion of, dermal contact with, and inhalation of VOCs from OU2 groundwater (if present) at less than 10 ft bgs at all five on-site EAs at OU2.
- **Future Construction Worker:** 1) Incidental ingestion of, dermal contact with, and inhalation of particulates and vapors from surface and subsurface soil at the Off-site Residential Area (EA6) and all five on-site EAs at OU2; and 2) incidental ingestion of, dermal contact with, and

inhalation of VOCs from OU2 groundwater (if present) at less than 10 ft bgs (incidental ingestion and dermal contact only) at all five on-site EAs at OU2.

Note: For the purposes of evaluating potential exposure to VOCs migrating from groundwater to air in construction trenches, groundwater at 10 ft bgs or deeper also is considered (VDEQ 2008).

- **Current and Future Trespasser (including child, adolescent, and adult trespassers):** 1) Incidental ingestion of, dermal contact with, and inhalation of particulates and vapors from surface soil and subsurface soil at all five on-site EAs at OU2; 2) inhalation of vapors from groundwater (selected OU2 EAs only); and 3) ingestion and dermal contact with surface water (selected OU2 EAs only).
- **Future Recreationalist (including child, adolescent, and adult recreationalists):** 1) Incidental ingestion of, dermal contact with, and inhalation of particulates and vapors from surface and subsurface soil at all five on-site EAs at OU2; and 2) inhalation of vapors from groundwater (selected OU2 EAs only); and 3) ingestion and dermal contact with surface water (selected OU2 EAs only).
- **Current and Future Resident (including child and adult residents):** 1) Incidental ingestion of, dermal contact with, and inhalation of particulates and vapors from produce grown in surface and subsurface soil at the Off-site Residential Area (EA6) and the Wooded Area – North (EA2) on-site EA; and 2) ingestion of, dermal contact with, and inhalation of VOCs from groundwater (Wooded Area – North [EA2] on-site EA only).

Receptor-specific intakes for each exposure route were calculated under both RME and CTE conditions using equations and exposure parameter values presented in the RAGS Part D 4 Series tables (included as part of Appendix RA-S1).

In addition to the exposure parameter values presented in Appendix RA-S1, the equations also included a medium-specific concentration that receptors were assumed to be exposed to. Appendix RA-3 presents the approach used to calculate medium-specific EPCs. For the RME and CTE cases, EPCs were calculated as the 95 percent UCL on the mean of each EA- and medium-specific data set using US EPA's ProUCL Version 4.00.04 statistical software package (US EPA 2009b). The EPC was selected as the 95 percent UCL of the statistical method result recommended by ProUCL. Statistical treatment was not conducted for constituents with less than eight detected results. In this circumstance, the maximum detected concentration was used as the EPC.

Groundwater presents unique circumstances that complicate the calculation of appropriate EPCs. Receptors are not expected to be exposed to groundwater from throughout an EA. For example, receptors may ingest groundwater from a well installed at a particular location or may have direct contact with groundwater in a construction trench at a particular location. For the purposes of the HHRA, a conservative approach was taken to investigate MWs that present the greatest expected risks and hazards to potential receptors.

For OU2, wells presenting the greatest expected risks and hazards were investigated based on comparison of maximum detected concentrations to risk-based screening levels (US EPA's RSLs) (US EPA 2009h). The wells with the highest cumulative total risk and hazard were shown as wells for which EPCs were calculated. For each EA-specific well listed below, EPCs were calculated in accordance with the approach presented in Appendix RA-3:

- EA1 – MW04 and MW31
- EA2 – MW15 and MW22
- EA3 – MW18
- EA4 – MW27
- EA5 – MW03, MW29, and MW30

Modeling was used to generate medium-specific EPCs for media not sampled directly. Specifically, modeling was used to estimate EPCs for blood lead, trench air, indoor air, and homegrown produce as summarized below.

- US EPA's IEUBK Model (US EPA 2009e) and the ALM (US EPA 2009d) were used to estimate receptor-specific lead screening levels as presented in Appendix RA-4 (US EPA 2003a).
- The concentrations of VOCs from groundwater in outdoor air within a construction or utility trench were estimated using a methodology developed by the VDEQ as part of its "Voluntary Remediation Program Risk Assessment Guidance" (VDEQ 2008).
- The migration of VOCs from underlying groundwater and soil into indoor air (subsurface vapor transport) was evaluated consistent with US EPA guidance, including "Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)" (US EPA 2002a) and "User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings" (US EPA 2004). US EPA's J&E model (Version 3.1) also was used.
- Concentrations of volatile constituents from groundwater in ambient air were estimated using

constituent-specific VFs calculated using equations from ASTM's "Standard Guide for Risk-Based Corrective Action" (ASTM 2004).

The risk assessment used the default toxicity values presented in the US EPA RSL tables (US EPA 2009h). The default values were obtained from the following sources in the order presented below:

- IRIS on-line database (US EPA 2010c)
- PPRTVs derived by US EPA's Superfund Health Risk Technical Support Center for the US EPA Superfund program
- ATSDR's MRL (ATSDR 2009)
- The CalEPA Office of Environmental Health Hazard Assessment's toxicity criteria (CalEPA 2003)
- US EPA Superfund program's HEAST (US EPA 1997b)

Toxicity values used in the HHRA are presented in Tables S5.1 and S5.2 (non-cancer toxicity values) and Tables S6.1 and S6.2 (cancer toxicity values) in Appendix RA-S1 (OU2). The tables contain slope factors (SF) and unit risk factors (URF) for carcinogenic effects and chronic reference doses (RfD) and reference concentrations (RfC) for chemicals with noncarcinogenic effects.

US EPA's IEUBK model and ALM were used to assess potential risks associated with exposure to lead for residents and non-residents, respectively (US EPA 2003a, 2009d, and 2009e). Specifically, the US EPA default RSLs of 400 and 800 mg/kg were utilized as the lead screening levels for residents and adult commercial/industrial workers (US EPA 2009h). Receptor-specific lead screening levels for utility workers, construction workers, trespassers, and recreationalists were developed under both RME and CTE conditions using US EPA's ALM and receptor-specific exposure parameters as described in Appendix RA-4. The table below summarizes the receptor-specific soil lead screening levels. Potential receptor-specific risks from exposure to lead in soil were calculated by comparing EA-specific soil lead EPCs to the calculated soil lead screening levels.

Receptor	Soil Lead Screening Level (mg/kg)	
	RME Conditions	CTE Conditions
Child and Adult Resident	400	400
Adult Commercial/Industrial Worker	800	800
Adult Utility Worker	12,262	24,524
Adult Construction Worker	941	2,038
Adult Site-Specific Worker	8,175	24,524
Adolescent Trespasser	6,563	13,438
Adult Trespasser	6,563	13,438
Child Recreationalist	896	1,552
Adolescent Recreationalist	6,563	13,438
Adult Recreationalist	6,563	13,438

Friable asbestos has been detected throughout OU2, especially in the Main Plant Area. Potential exposure is expected to occur through inhalation. For the purposes of this HHRA, site-specific activity-based air sampling results were compared to receptor-specific asbestos action levels (AL). These ALs were calculated using the following equation from US EPA's "Framework for Investigating Asbestos-Contaminated Superfund Sites" (US EPA 2008c).

$$\text{Asbestos AL (f/cc)} = \text{TR} / (\text{IURLTL} \times [\text{ET} \times 24 \text{ hours/day}] \times [\text{EF}/365 \text{ days/year}])$$

where

TR = Target risk (unitless)

IURLTL = Less-than-lifetime inhalation unit risk (f/cc)⁻¹

ET = Exposure time (hours/day)

EF = Exposure frequency (days/year)

As discussed in Section 1.2.3.4 in Appendix RA (HHRA), activity-based asbestos air samples (ABS and RAFS samples) were collected from EA1 (Main Plant Area) and EA4 (Building 100 Hot Spot) only. Future residential exposure in these EAs was not assumed. Therefore, an asbestos PRG was not developed for residents. The remaining human receptors that could be exposed to airborne asbestos in OU2 EA1 and EA4 are adult commercial/industrial workers; adult utility workers; adult construction workers; adolescent and adult trespassers; and child, adolescent, and adult recreationalists. Asbestos PRGs were calculated for these receptors using exposure parameter values (ET and EF) as presented in

the OU2 RAGS D tables (Appendix RA-S1). Tables RA-S2-5A and RA-S2-5B, respectively, in Appendix RA, present the receptor-specific asbestos ALs calculated under RME and CTE conditions.

7.2.4 HHRA Results

The following sections discuss the risk characterization results for each OU2 EA and the results of a hot-spot analysis requested by IEPA. The RAGS D Table 7 Series (Appendix RA-S1) list the EPCs, ADD and average daily exposure, toxicity values, and calculated cancer risks and non-cancer hazards. The RAGS D Tables Series 9 and 10 summarize the risks and hazards for each EA.

7.2.4.1 Summary of Risks and Hazards at the Main Plant Area (EA1)

Potential risks and hazards were evaluated for eight receptor types at EA1: future commercial/industrial worker, future utility worker, future construction worker, current/future adolescent trespasser, current/future adult trespasser, future child, adolescent, and adult recreationalists. Risks and hazards for each receptor type are summarized in Table RA-S2-50 and below in terms of chemical-, lead-, and asbestos-specific results.

7.2.4.2 Summary of Risks and Hazards at the Main Plant Area (EA2)

Potential risks and hazards were evaluated for nine receptor types at EA2: commercial/industrial worker, utility worker, construction worker, adolescent trespasser, adult trespasser, child recreationalist, adolescent recreationalist, adult recreationalist, and future resident. Risks and hazards for each receptor type are summarized in Table RA-S2-51 and below in terms of chemical-, lead-, and asbestos-specific results.

- Chemical-specific risks: Total risks are within US EPA's acceptable risk range for the commercial/industrial worker (both RME and CTE conditions), utility worker (RME conditions only), and construction worker (RME conditions only) and are driven by potential exposure to arsenic in soil and to groundwater (MW22). Total risks are considered insignificant for the adolescent trespasser, adult trespasser, child recreationalist, adolescent recreationalist, and adult recreationalist. Finally, total risks for residents exceed US EPA's acceptable risk range for the non-intrusive and intrusive scenarios (both RME and CTE conditions). Risks are driven by potential exposure to arsenic, hexavalent chromium, and carcinogenic PAHs in soil (and produce for residents) and by potential exposure to groundwater (see Section 2.7.2.1 in Appendix RA).

- Chemical-specific hazards: Total hazards exceed 1 for commercial/industrial workers and construction workers and are driven by hexavalent chromium in groundwater (commercial/industrial workers) and zinc in soil (construction workers). Total hazards are less than 1 and considered insignificant for the utility worker, adolescent trespasser, adult trespasser, child recreationalist, adolescent recreationalist, and adult recreationalist under all conditions. Total hazards for residents exceed 1 under both non-intrusive and intrusive scenarios and under both RME and CTE conditions and are driven by potential exposure to cadmium in soil, to various metals in produce, and to groundwater (see Section 2.7.2.1 in Appendix RA).
- Lead: Lead presents a potential risk to the construction worker (both RME and CTE conditions) and to residents under the non-intrusive scenario (both RME and CTE conditions).
- Asbestos: Asbestos does not present a risk to any receptor type.

7.2.4.3 Summary of Risks and Hazards at the Main Plant Area (EA3)

Potential risks and hazards were evaluated for seven receptor types at EA3: utility worker, construction worker, adolescent trespasser, adult trespasser, child recreationalist, adolescent recreationalist, and adult recreationalist. Risks and hazards for each receptor type are summarized in Table RA-S2-52 and below in terms of chemical-, lead-, and asbestos-specific results.

- Chemical-specific risks: Total risks are within US EPA's acceptable risk range for the utility worker (RME conditions only), construction worker (RME conditions only), and child recreationalist (non-intrusive and intrusive RME conditions only) and are driven by potential exposure to arsenic in soil. Total risks are considered insignificant for all other receptors.
- Chemical-specific hazards: Total hazards exceed 1 for the construction worker only (maximum HI = 4.8) (RME conditions only) and are driven by potential exposure to arsenic in soil. Total hazards are less than 1 and considered insignificant for all other receptors.
- Lead: Lead presents a potential risk to the construction worker only (RME and CTE conditions).
- Asbestos: Asbestos does not present a risk to any receptor type.

7.2.4.4 Summary of Risks and Hazards at the Building 100 Hotspot (EA4)

Potential risks and hazards were evaluated for eight receptor types at EA4: commercial/industrial worker, utility worker, construction worker, adolescent trespasser, adult trespasser, child recreationalist, adolescent recreationalist, and adult recreationalist. Risks and hazards for each receptor type are summarized in Table RA-S2-53 and below in terms of chemical-, lead-, and asbestos-specific results.

- Chemical-specific risks: Total risks exceed US EPA's acceptable risk range for the commercial/industrial worker (non-intrusive and intrusive scenarios, RME conditions) and are within US EPA's acceptable risk range for all other receptors (both RME and CTE conditions). Total risks are considered insignificant for the adolescent and adult trespassers and adolescent and adult recreationalists under CTE conditions. Total risks are driven by potential exposure to some combination of Aroclor-1260, arsenic, and benzo(a)pyrene in soil.
- Chemical-specific hazards: Total hazards are greater than 1 under all conditions for the commercial/industrial worker and child recreationalist under RME conditions only for all other receptors. Total hazards are driven by potential exposure to Aroclor-1260 in soil (commercial/industrial worker, utility worker, construction worker, and child recreationalist), manganese in soil (commercial/industrial worker and construction worker), arsenic in soil (construction worker only), and groundwater (commercial/industrial worker only).
- Lead: Lead presents a potential risk to the commercial/industrial worker (both RME and CTE conditions), construction worker (both RME and CTE conditions), and child recreationalist (non-intrusive and intrusive RME and CTE conditions).
- Asbestos: Asbestos presents a potential risk only to commercial/industrial workers under the non-intrusive scenario (RME and CTE conditions). Asbestos presents no risks to the other receptors.

7.2.4.5 Summary of Risks and Hazards at the Rolling Mill Area (EA5)

Potential risks and hazards were evaluated for eight receptor types at EA5: commercial/industrial worker, utility worker, construction worker, adolescent trespasser, adult trespasser, child recreationalist, adolescent recreationalist, and adult recreationalist. Risks and hazards for each receptor type are summarized in Table RA-S2-54 and below in terms of chemical-, lead-, and asbestos-specific results.

- Chemical-specific risks: Total risks are within US EPA's acceptable risk range under all scenarios and RME and CTE conditions for the commercial/industrial worker, utility worker, construction worker, and child recreationalist and are within US EPA's acceptable risk range under RME conditions only (all scenarios) for the adolescent trespasser, adult trespasser, adolescent recreationalist, and adult recreationalist. Total risks are driven by potential exposure to some combination of carcinogenic PAHs (especially benzo(a)pyrene), arsenic, and Aroclor-1248.

- Chemical-specific hazards: Total hazards are greater than 1 for the commercial/industrial worker (all scenarios and conditions), utility worker (RME and CTE conditions), construction worker (RME and CTE conditions), and child recreationalist (non-intrusive scenario, RME conditions only). These risks are driven by potential inhalation of particulates containing cyanide and ingestion of Aroclor-1248, zinc, and copper in soil (construction worker only). As discussed in Section 2.6.3 of Appendix RA, it is very unlikely that cyanide actually poses a hazard. Cyanide-specific hazards are linked to the use of an RfC for hydrogen cyanide, which is unstable in ambient air.
- Lead: Lead presents a potential risk to the commercial/industrial worker (nonintrusive and intrusive scenarios both RME and CTE conditions), construction worker (both RME and CTE conditions), and child recreationalist (non-intrusive scenario, RME conditions only, and intrusive scenario, RME and CTE conditions).
- Asbestos: Asbestos does not present a risk to any receptor type.

7.2.4.6 Summary of Risks and Hazards at the Off-Site Residential Area (EA6)

Potential risks and hazards were evaluated for three receptor types at EA6: utility worker, construction worker, and residents. Risks and hazards for each receptor type are summarized in Table RA-S2-55 and below in terms of chemical-, lead-, and asbestos-specific results.

- Chemical-specific risks: Total risks are within US EPA's acceptable risk range for the utility worker (both RME and CTE conditions) and construction worker (RME conditions only). Total risks for residents are less than or equal to 1×10^{-6} at 50 of 185 individual properties (27 percent) and exceed US EPA's acceptable risk range at 24 individual properties (RME conditions only). Total risks are driven by potential exposure to arsenic in soil for the utility worker and construction worker and to arsenic and hexavalent chromium in soil and produce for residents. Risks for hexavalent chromium are based on an assumed ratio of 1:6 (about 14 percent hexavalent and 86 percent trivalent chromium) for hexavalent:trivalent chromium in soil. To the extent the percentage of hexavalent chromium is less than 14 percent, risks associated with potential exposure to hexavalent chromium will be reduced. However, for EA6, most of the soil and produce risks are due to arsenic rather than hexavalent chromium.
- Chemical-specific hazards: Total hazards are greater than 1 for the construction worker under RME conditions (all COPC-specific hazards are less than 1) and for residents (RME conditions) at 152 of 185 individual properties (82 percent) and are driven by potential exposure to antimony,

arsenic, cadmium, manganese, and zinc soil and through ingestion of homegrown produce (residents only).

- Lead: Lead presents a potential risk to the construction worker (both RME [four properties] and CTE [single location] conditions) and residents (RME and CTE conditions) at 46 of 185 individual properties (25 percent).
- Asbestos: Asbestos does not present a risk to any receptor type.

7.2.4.7 Summary of Risks and Hazards at the Off-Site Mixed-Use Area (EA7)

Potential risks and hazards were evaluated for three receptor types at EA7: child, adolescent, and adult recreationalists. Risks and hazards for each receptor type are summarized in Table RA-S2-56 and below in terms of chemical-, lead-, and asbestos-specific results.

- Chemical-specific risks: Total risks are within US EPA's acceptable risk range for the child recreationalist (RME conditions only; all COPC-specific risks were less than 1×10^{-6}). Total risks are considered insignificant for all other receptor types and conditions.
- Chemical-specific hazards: Total hazards are less than 1 and considered insignificant for all receptors under both RME and CTE conditions.
- Lead: Lead does not present a risk to any receptor type.
- Asbestos: Asbestos does not present a risk to any receptor type.

7.2.4.8 Hot-Spot Analysis

At the request of IEPA, detected concentrations in soil were compared to chemical-specific TACO remediation objectives (RO) for construction workers (IEPA 2008). Specifically, all detected constituent concentrations in soil samples collected from OU2 were compared to the lower of available ingestion- and inhalation-based TACO construction worker soil ROs. Based on these comparisons, the following constituents were measured in surface (0 to 2 ft bgs) or subsurface (0 to 10 ft bgs) soil samples at concentrations exceeding the TACO construction worker soil ROs:

- | | |
|------------|----------------|
| • Antimony | • Manganese |
| • Arsenic | • Mercury |
| • Cadmium | • Zinc |
| • Copper | • Aroclor-1248 |
| • Lead | • Aroclor-1254 |

- Aroclor-1260
- Benzo(a)pyrene
- Naphthalene
- TCE

The distribution of concentrations exceeding the ROs for these constituents provides some evidence of a grouping or clustering of elevated concentrations, so-called “hot spots.”

Each OU2 EA was evaluated for the number of constituents present at concentrations exceeding their respective TACO construction worker soil ROs. The results are as follows:

- EA1, 12 constituents
- EA2, 5 constituents
- EA3, 4 constituents
- EA4, 6 constituents
- EA5, 9 constituents
- EA6, 3 constituents
- EA7, 4 constituents

Not unexpectedly, EA1, EA5, and EA4 had the most exceedances. Additional evaluation revealed that at the following 13 locations, the greatest number of constituents exceeded their respective TACO construction worker ROs (a decision was made to limit the following list to locations with four or more constituents exceeding the RO):

- SB054A
- SB185A
- SB140A
- P051
- P008S
- SB043B (SB043A also had three constituents with exceedances)
- SB098A
- P044
- SB214B
- P046
- SB017A (SB017B also had one constituent with an exceedance)
- SB019A
- SB409A-08

The EAs for each of these sampling locations and the number of constituents detected at concentrations exceeding the TACO construction worker ROs are as follows:

- EA1 – SB054A (six), SB185A (six), P008S (four), SB043B (four), SB098A (four), P044 (four), SB214B (four), P046 (four), and SB017A (four)
- EA4 – P051 (five), SB019A (four), and SB409A-08 (four)
- EA5 – SB140A (five)

The constituents detected at concentrations exceeding their respective TACO construction worker ROs are lead, mercury, Aroclor-1260, and benzo(a)pyrene. The number of mercury exceedances may be overstated. Correlations between mercury results based on XRF analysis and formal laboratory analysis could not be established; the XRF results were inconsistent and appeared to be elevated. As a result, only the formal laboratory analysis results for mercury were considered in calculating EPCs for mercury in surface soil. However, the number of exceedances inadvertently includes XRF results as well. Therefore, the number of mercury exceedances is overstated.

Figures RA-S1-1 and RA-S1-2 in Appendix RA show the locations of the sampling locations listed above. Several important observations were made based on review of these figures. Sampling location SB140 is located along the western boundary of the Rolling Mill (EA5), and sampling location SB185A is located at the southeast corner of Building 143 (dry storage), which is immediately east of the Rolling Mill. The remaining 11 sampling locations are located within an east-west band measuring about 600 ft from north to south across the heavily industrial portion of EA1. The northern extent of this band is the reservoir, with the pump house located northeast of Building 100, and the southern extent of this band is about 450 ft north of the Rolling Mill. This situation indicates that in the northern third or so of EA1 and in all of EA1 and EA3, no results exceeded the TACO construction worker ROs.

7.2.5 Uncertainties

The OU2 HHRA has a variety of sources of uncertainty which are specifically detailed in Section 2.6.3 of Appendix RA. In summary, the general sources of uncertainty are associated with the CSM, analytical data, exposure estimates, toxicity factors, and sources. OU2-specific sources of uncertainty include use of maximum detected concentrations to characterize risks and hazards for utility and construction workers, use of default soil-to-plant uptake factors, use of default relative bioavailability values, use of toxicity factors based on hydrogen cyanide for cyanide, potential impacts of elevated detection limits on EPC calculations, use of default hexavalent chromium results, and the impact of limited asbestos air sampling.

7.2.6 Overall HHRA Conclusions for OU2

Based on the risks and hazard detailed in the OU2 HHRA, the overall conclusions summarized below can be drawn.

- Potential risks exceeding US EPA's acceptable risk range were shown for EA1 (utility worker), EA2 (resident), EA4 (commercial/industrial worker), and EA6 (resident) under RME conditions for both current and future land use (and non-intrusive and intrusive) scenarios. Under CTE conditions, potential risks for these EA-receptor combinations are within US EPA's acceptable risk range except for EA2 (residents).
- EA3 and EA7 have the lowest risks and hazards. EA7 has a calculated risk of 1×10^{-6} for the child recreationalist under RME conditions.
- Potential exposure to COPCs in groundwater presents limited risks and hazards unless potable use of groundwater is assumed.
- The highest risks and hazards were shown for the commercial/industrial worker and the resident, and the lowest risks and hazards were shown for the adolescent and adult trespassers and the adolescent and adult recreationalists.
- Soil risks are driven by potential exposure to arsenic, benzo(a)pyrene (and other carcinogenic PAHs), Aroclor-1248, Aroclor-1260, and hexavalent chromium (likely overstated).
- Soil hazards are driven by potential exposure to metals (primarily arsenic, cadmium, manganese, and zinc), cyanide (very likely overstated; see Section 2.6.3.4 in Appendix RA), and Aroclor-1260 (primarily at EA4).
- Lead presents a potential risk to at least one receptor in all EAs except EA7. Lead poses a potential risk to the following receptor types: construction worker (EA1 through EA6), utility worker (EA1 only), commercial/industrial worker and child recreationalist (EA1, EA4, and EA5), and resident (EA6 at some locations).
- Asbestos presents a potential risk to the commercial/industrial worker at EA1 and EA4 and presents no risks to any receptor types at EA2, EA3, EA5, EA6, and EA7.

7.3 SITE-WIDE HUMAN HEALTH RISK ASSESSMENT

For the purposes of the RI, US EPA divided the Matthiessen and Hegeler Zinc Company Site into two OUs – OU1 and OU2. OU1 consists of the Carus Plant Area and areas to the east, including the Slag Pile Area, and the LVR. OU2 mainly consists of the former Matthiessen and Hegeler facility, but also includes an Off-Site Residential Area and an Off-Site Mixed Use Area. A set of receptors and exposure

assumptions was developed for each OU to evaluate current and future risks within that OU. This risk assessment did not quantitatively consider potential risks for receptors exposed to more than one EA or to both OUs. An evaluation was conducted to account for the possibility that a single receptor might have exposures that include both OU1 and OU2.

Because of the number of receptor-exposure pathways involved at each OU, there are numerous potential combinations. Some of these combinations are more relevant than others. Pathways associated with current residential (OU2) and industrial (OU1) receptors which may have secondary exposures while trespassing or recreating at other areas of the Site are the most appropriate to consider for this evaluation. Other scenarios are associated with a higher degree of uncertainty. For example, utility/construction workers are assumed to be exposed solely to the highest concentration point in each OU. As such, the calculated risks at each OU already represent a “worst case” scenario. Summing non-cancer risks to an individual receptor through time (e.g., from childhood resident to adult worker) is also problematic, as individual HQs are based on average daily intake, and thus, the non-cancer risk should simply be based on the most sensitive time.

Table RA-2-1 of Appendix RA presents several potential cross-OU risk scenarios. These risk scenarios focus on current workers at OU1 that may trespass at OU2, and current workers and residents at OU2 that may trespass or participate in recreational activities (including fishing and fish consumption) at OU1.

Generally, risks calculated for worker and residential scenarios were greater than those for trespassing or recreating. Thus, although additional on-site activities may contribute to overall risk, the increase in risk is modest.

8.0 ECOLOGICAL RISK ASSESSMENT

The purpose of an ERA is to evaluate the likelihood that adverse ecological effects are occurring or may potentially occur as a result of site-specific constituent concentrations in environmental media. The ERA conservatively characterized ecological risks potentially associated with the Matthiessen and Hegeler Zinc Company Site under conditions at the time of the RI (i.e., unremediated conditions).

The ERA for the Matthiessen and Hegeler Zinc Company Site was performed in accordance with the US EPA *Ecological Risk Assessment Guidance for Superfund* (ERAGS; US EPA 1997a) eight-step process. The components of the ERAGs process are:

- Step 1 - Screening Level Problem Formulation;
- Step 2 - Screening Level Exposure Estimate and Risk Calculation;
- Step 3 - Baseline Problem Formulation;
- Step 4 - Study Design and Data Quality Objective (DQO) Process;
- Step 5 - Verification of Field Sampling Design;
- Step 6 - Site Investigation and Data Analysis;
- Step 7 - Risk Characterization; and
- Step 8 - Risk Management.

Section 3.0 of the Risk Assessment document presents Steps 1 and 2 (i.e., SLERA), and Section 4.0 of the Risk Assessment document presents Steps 3 through 7 for habitats that warranted further evaluation in a BERA. The Risk Assessment document is a companion document to the RI Report and is included as Appendix RA. Risk Management (Step 8) will be addressed in the FS.

The following sections discuss the ERA for the Matthiessen and Hegeler Zinc Company Site as it applies to OU1 ([Section 8.1](#)) and OU2 ([Section 8.2](#)).

8.1 OU1 ECOLOGICAL RISK ASSESSMENT

The following sections summarize the OU1 screening level ERA (Steps 1 and 2) and the OU1 baseline ERA (Steps 3 through 7).

8.1.1 OU1 Screening Level Ecological Risk Assessment (Steps 1 and 2)

The primary objective of Step 1 (screening level problem formulation) is to collect sufficient information concerning the Site to develop a preliminary ecological CSM. This step considers the Site setting and environment, nature and extent of contamination, potential fate and transport processes, and ecological characteristics of the Site. In October 2007, Geosyntec conducted an ecological habitat characterization survey of OU1 by means of a site walk and visual observation. Habitat characterization activities focused on the three EAs of OU1. Flora and fauna observed at OU1 are tabulated in Table E-G1-2 of Appendix RA-E-G1. Within the three OU1 EAs, Geosyntec investigated the following dominant habitat types:

- Carus Plant Area – highly disturbed habitat
- Slag Pile Area – disturbed habitat with vegetation and highly disturbed habitat
- LVR – riverine/riparian habitat

Using this information, a preliminary ecological CSM was prepared which investigated likely categories of receptors with anticipated complete exposure pathways, and investigated assessment endpoints (AE) for the ecological evaluation. Potential direct exposure points investigated for ecological receptors at OU1 include soil at the Slag Pile and sediment and surface water in the LVR. While the potential for direct exposure at the Carus Plant is extremely limited, it was treated as a complete exposure pathway to provide risk managers with a point-of-departure of making decisions in subsequent steps of the SLERA process. Thus, the following exposure pathways were evaluated in the OU1 SLERA:

- Exposure of terrestrial receptors to constituents in surface soil at the Carus Plant (highly disturbed habitat)
- Exposure of terrestrial receptors to constituents in surface soil at the Slag Pile (highly disturbed habitat and disturbed habitat with vegetation)
- Exposure of benthic, aquatic, and semi-aquatic receptors to constituents in sediment and surface water of the LVR (riverine/riparian habitat)

The specific AEs evaluated in the OU1 SLERA were as follows:

- Ensure adequate protection of terrestrial plant and soil communities, including native plant communities, by protecting them from the deleterious effects of acute and chronic exposures to site-related constituents.
- Ensure adequate protection of mammalian and avian populations by protecting them from the deleterious effects of acute and chronic exposures to site-related constituents.

- Ensure adequate protection of threatened and endangered species (including candidate species) and species of special concern and their habitats by protecting them from the deleterious effects of acute and chronic exposures to site-related constituents.
- Ensure adequate protection of the benthic and aquatic communities in LVR by protecting them from the deleterious effects of acute and chronic exposures to site-related constituents present in the river.
- Ensure adequate protection of the aquatic-dependent mammalian and avian populations along the shoreline of the LVR by protecting them from the deleterious effects of acute and chronic exposures to site-related constituents due to biotic uptake of constituents in sediment and surface water.

The final component of Step 1 is the screening level ecological effects evaluation, which investigates threshold concentrations for constituents in environmental media below which adverse effects are not expected to occur. These highly conservative constituent concentrations (ecological SVs or ESVs) are unlikely to result in adverse ecological effects even to the most sensitive ecological receptors. ESVs are used as bases to evaluate if adverse ecological effects could result from exposure to constituents in environmental media. As detailed in the SLERA, ESVs were selected from a hierarchy of sources taking into account confidence in the scientific basis for the SVs.

In Step 2 of the ERA (screening level exposure estimate), maximum detected concentrations (conservative estimate of EPCs) of constituents detected in each ecological exposure medium and EA are compared with the conservative ESVs investigated in Step 1 to yield a HQ as follows:

$$HQ = \frac{EPC}{ESV}$$

The US EPA HQ threshold value of 1 was used to investigate COPECs in the OU1 SLERA. Step 2 also describes any potential uncertainties associated with the SLERA. At OU1, the following were investigated as sources of uncertainty: 1) the assumption that disturbed habitats represent potentially complete exposure pathways; 2) the use of available analytical data (including data collected during the 1990s); 3) the assumption that ecological receptors are exposed to the maximum concentration at the Site 100 percent of the time; and 4) the assumption that constituents in environmental media are 100 percent bioavailable.

Following Step 2, there is a scientific management decision point (SMDP) at which risk managers evaluate whether further ecological evaluation is warranted. The SMDP considers the quantitative results of the SLERA as well as the uncertainty associated with those risks. Further evaluation is conducted for those habitats investigated in the SLERA that have potentially unacceptable risks, provide significant ecological habitat, and where additional site-specific investigation may guide risk management decisions.

The results of the OU1 SLERA and SMDP support the following conclusions and recommendations:

- Concentrations of several constituents, primarily metals, in surface soil at the Carus Plant exceed SLERA ESVs for terrestrial wildlife receptors. However, the Carus Plant does not offer suitable ecological habitat due to the significant physical alterations to the landscape. Therefore, this is an incomplete exposure pathway and further evaluation in a BERA is not warranted.
- Concentrations of several constituents, primarily metals, in surface soil at the Slag Pile exceed SLERA ESVs for terrestrial wildlife receptors. Limited vegetation and wildlife receptors have been observed at the Slag Pile; however, the physical substrate (slag) creates poor habitat for ecological receptors. The results of the phytotoxicity tests also support the SLERA results that constituents in Slag Pile soil have the potential to adversely affect ecological receptors. Therefore, additional ecological evaluation in a BERA is not recommended as it will not significantly refine risk estimates. Therefore, further evaluation in a BERA is not warranted.
- Concentrations of several constituents, primarily metals, in the sediment and surface water of the LVR exceed SLERA ESVs for benthic and aquatic receptors. The LVR is the most ecologically valuable habitat associated with the Site. Therefore, further evaluation in a BERA is recommended for this riverine/riparian habitat.

In summary, ecological risks associated with the terrestrial portions of the Site (i.e., the Carus Plant Area and the Slag Pile Area) do not warrant further evaluation in a BERA; remedial goals for these EAs in the FS will be based on the results of the SLERA. The LVR BERA, which further characterizes potential ecological risks in the LVR, is presented in Section 4.1 of Appendix RA and summarized below in [Section 8.1.2](#).

8.1.2 OU1 LVR Baseline Ecological Risk Assessment (Steps 3 through 7)

The results of SLERA indicated that concentrations of several constituents in the LVR, primarily metals, exceeded the sediment and/or SW ESVs, which was the SLERA metric for predicting potential adverse ecological effects to benthic and aquatic receptors. Because the LVR is the most ecologically valuable

habitat associated with the OU1 and it was likely that additional assessment would refine ecological risk estimates and inform risk management decisions, further evaluation in a BERA was recommended.

In order to expedite the completion of the BERA and RI Report, risk assessors from SulTRAC, Geosyntec, and US EPA met in March 2008 to develop a FSP for the 2009 Phase II RI, which would meet the anticipated needs of the BERA. Although the SLERA had not been completed, the risk assessors used the available analytical data (i.e., 2007 Phase I RI and earlier data) and Site characterization to investigate habitats that would likely warrant further evaluation in a BERA. (Note: the results of the SLERA were generally consistent with the anticipated results discussed in the March 2008 meeting.) The highest quality habitats at the Site, which represent the most valuable ecological resource at the Site, were recommended for further evaluation; for OU1, the riverine/riparian habitat of the LVR was recommended for further evaluation.

8.1.2.1 **Baseline Problem Formulation (Step 3)**

The objective of the Baseline Problem Formulation is to refine exposure and toxicity estimates used in the SLERA to provide a more realistic evaluation of potential ecological risks associated with exposure to environmental media in the LVR. Step 3 includes the following components:

- Review and refinement of complete ecological exposure pathways and COPECs
- Further characterization of ecological effects of COPECs
- Selection of AEs for the BERA

The following exposure pathways were identified as potentially complete and recommended for further evaluation in the BERA:

- Exposure of upper trophic-level wildlife (mammalian and avian) receptors to constituents that could bioaccumulated/bioconcentrated up the food chain into prey biota
- Exposure of benthic receptors to constituents in sediment of the LVR
- Exposure of aquatic (fish) receptors to constituents in sediment and surface water of the LVR

A river characterization program was developed to evaluate the potentially complete exposure pathways described above. The program consisted of: (1) collection of additional sediment and surface water samples for chemical analysis; (2) collection of biotic tissue samples; (3) collection of sieved sediment samples for toxicity testing; and (4) assessment of benthic and aquatic (fish) communities. Together,

these lines of evidence are used to characterize the overall status of the ecological community within and along the shoreline of the LVR.

A refined COPEC list was developed for evaluation in the BERA. The list was developed such that the assessment focused on chemicals with the greatest potential for concern, while still ensuring that there is sufficient information to develop appropriate remedial strategies to protect the ecosystem. BERA COPECs were selected based on one or more of the following criteria: (1) potentially site-related; (2) exceeded US EPA Region 5 ESLs (US EPA 2003b) in sediment; (3) frequently detected in the Phase I RI data; and (4) potentially bioaccumulative. The BERA COPEC list consisted of the following:

- Arsenic
- Cadmium
- Copper
- Lead
- Mercury
- Silver
- Zinc

Although the remaining constituents investigated as preliminary COPECs in the SLERA were not specifically evaluated in the BERA, their potential effects are inherently characterized through the toxicity testing and community assessments. Note: the TAL for the sediment and surface water samples collected during the Phase II RI was consistent with that of the Phase I RI (i.e., it was not limited to the BERA COPECs); however, the TAL for biotic tissue samples collected in the Phase II RI was limited to the seven BERA COPECs.

Characterization of Ecological Effects

The BERA began with a refined analysis of COPECs (arsenic, cadmium, copper, lead, mercury, silver, and zinc) that compared location-specific concentrations in sediment and surface water to risk-based effects concentrations (ESVs). ESVs do not take account of site-specific factors, such as possible limited bioavailability of COPECs. For sediment, two ESVs from MacDonald et al. (2000) were considered – the TEC and probable effects concentration (PEC) or, if a TEC/PEC was not available, comparable thresholds from the National Oceanic and Atmospheric Administration (NOAA 1999). For surface water, COPEC concentrations were compared to IWQS or, if an IWQS was not available, the Region 5 ESL. This analysis evaluated the frequency, magnitude, and spatial location (i.e., upgradient, beside, or downgradient of the Site) of exceedances of the ESVs for individual COPECs.

COPECs in sediment exceeded TECs in multiple locations; however, with the exception of cadmium and zinc, the majority of reported COPEC concentrations were below the TEC or within the range of the TEC

and PEC values. Cadmium and zinc more frequently exceed their respective PECs than other COPECs. Spatially, the highest COPEC concentrations are associated with samples collected near the outfall of the ASO and CSO, which are immediately upstream of the head of the Slag Pile and immediately upstream of CAR003. Notably, reported COPEC concentrations tended to be higher in the samples collected before 1995, although for certain COPECs (e.g., zinc), comparable concentrations have also been reported in more recent (2007 and 2009) samples.

As part of this refined analysis, site-specific bioavailability data (SEP results) for stream-weathered slag material were also reviewed. BERA COPECs were frequently non-detect in the bioavailable fractions or present at low concentrations relative to other fractions. The bioavailability of cadmium and zinc, the COPECs that most frequently exceeded the TECs/PECs, were estimated to be approximately 27 percent and 1.3 percent, respectively. This conclusion is also supported by the low concentrations of COPECs in the sieved samples analyzed as part of the toxicity testing discussed below. Thus, predicting risks to ecological receptors based solely on exceedances of ESVs, which assume 100 percent bioavailability, almost certainly over-predicts the actual potential for adverse ecological effects.

Relative to media-specific screening criteria, concentrations in surface water were generally lower than concentrations in sediment (i.e., lower ratio of concentration to screening criteria [HQ]). For most COPECs, exceedances of SW ESVs (i.e., IWQS/Region 5 ESL) are primarily limited to samples collected from or adjacent to the ASO and CSO. Zinc, however, exceeds its IWQS at the majority of sampling locations, but even with zinc, the ASO and CSO concentrations are more than two orders of magnitude greater than the average of the remaining samples collected adjacent to the Site. As with sediment ESVs, SW ESVs do not consider site-specific conditions, such as ecological receptors present or water chemistry.

Given the uncertainty associated with the use of literature-derived effects estimates, the remainder of the BERA focused on using more site-specific approaches to characterize ecological effects. However, the information above was also incorporated into the weight-of-evidence discussion.

Assessment Endpoints

The AEs for the LVR, which were presented in the Consensus Document, were selected based on three principal criteria: 1) ecological relevance; 2) susceptibility to potential stressors; and 3) representation of management goals. The OU1 AEs considered in the BERA are as follows:

- Survival and reproduction of mammalian populations that feed/forage in the LVR adjacent to the Site
- Survival and reproduction of avian populations that feed/forage in the LVR adjacent to the Site
- Function and viability of the benthic communities in the LVR adjacent to the Site
- Function and viability of the aquatic (fish) communities in the LVR adjacent to the Site

8.1.2.2 Measurement Endpoints and Study Design (Step 4)

Refinement of the ecological CSM, which began in Step 3 and included refinement of exposure pathways, definition of AEs, and development of risk questions, is completed in Step 4 with the selection of measurement endpoints. Measurement endpoints are measurable parameters that can be used to evaluate the response of an AE to contaminant exposure. Step 4 also shows the site investigation methods (i.e., study design) and data interpretation techniques used to support the risk characterization for each measurement endpoint.

The measurement endpoints used to evaluate potential risk to each of the four ecological AEs are as follows:

- ***Survival and reproduction of mammalian populations that feed/forage in the LVR adjacent to the Site:*** A food chain model (FCM) is used to calculate the ADD of COPECs to mammalian receptors that feed/forage in the LVR adjacent to the Site. The ADD is based on ingestion of COPECs in sediment, surface water, and prey tissue. The ADD is compared to low and high dietary toxicity reference values (TRVs) to calculate potential risks to the survival and reproduction of mammalian populations.
- ***Survival and reproduction of avian populations that feed/forage in the LVR adjacent to the Site:*** A FCM is utilized to calculate an ADD from ingestion of COPECs to avian receptors that feed/forage in the LVR adjacent to the Site. The ADD is based on ingestion of COPECs in sediment, surface water, and prey tissue. The ADD is compared to low and high TRVs to calculate potential risks to the survival and reproduction of avian populations.
- ***Function and viability of the benthic communities in the LVR adjacent to the Site:*** Sediment toxicity testing was conducted using two species of benthic macroinvertebrates and comparing results from the Site to an upstream reference reach. In addition, a benthic macroinvertebrate community assessment was conducted and the results were used to calculate various indices to quantitatively evaluate the function and viability of the benthic macroinvertebrate community.

- ***Function and viability of the aquatic (fish) communities in the LVR adjacent to the Site:*** A fish community assessment was conducted and the results were used to calculate various indices to quantitatively evaluate the function and viability of the fish community.

The BERA study design consisted of the following primary elements, presented in order of site-specificity:

- Comparison of location-specific concentrations in sediment and surface water to ESVs ([Section 8.1.2.1](#))
- FCM to evaluate potential risks to mammalian receptors from ingestion of sediment, surface water, and prey tissue in the LVR adjacent to the Site
- FCM to evaluate potential risks to avian receptors from ingestion of sediment, surface water, and prey tissue in the LVR adjacent to the Site
- Acute and chronic sediment toxicity tests to evaluate potential risks to macroinvertebrates exposed to sediment in the LVR adjacent to the Site
- Biological community assessments designed to evaluate potential risk to benthic macroinvertebrates and aquatic (fish) communities exposed to sediment and surface water in the LVR adjacent to the Site

The potential effects of COPECs in the LVR adjacent to the Site on the survival and reproduction of mammalian and avian populations that feed/forage in the area is evaluated using FCMs. FCMs estimate the dose (i.e., ADD) of COPECs to upper trophic level receptors based on the ingestion of COPECs in sediment, surface water, and prey items. An HQ approach was used as the measurement endpoint to evaluate potential impacts from COPECs on the survival and reproduction of mammalian and avian populations that forage/feed in the LVR adjacent to the Site. Total exposure (ADD) was estimated using measured COPEC levels in sediment, surface water, and prey tissue (mussels and whole body fish) and receptor-specific exposure assumptions in an ingestion calculation. Sediment and surface water EPCs were calculated using ProUCL 4.00.04 (US EPA 2009b). Because of the limited sample sizes, maximum detected concentrations in fish and mussel tissue were selected to represent the EPCs in fish and mussel tissue. Representative receptor species were selected based on their susceptibility to the site-related constituents, and the amount of available data describing their potential for exposure and toxicological effects that may result from exposure. Based on these considerations, a mink (*Mustela vison*) and belted kingfisher (*Megasceryle alcyon*) were selected to represent the mammalian and avian communities, respectively. No Observable Adverse Effect Level (NOAEL) and Lowest Observable Adverse Effect Level (LOAEL) dietary TRVs were used as low and high benchmarks, respectively, to evaluate potential

risks to upper trophic level receptors. ADDs for each receptor were compared with selected NOAEL and LOAEL TRVs to calculate a risk estimate (HQ). For the purposes of the BERA a LOAEL HQ of 1 was selected as the benchmark to investigate primary ecological risk-drivers at the Site.

Sediment toxicity testing, which exposes naïve (laboratory) organisms to site sediment, is used as one line of evidence to evaluate potential risks to benthic macroinvertebrates of the LVR. The results of the sediment toxicity testing were used to evaluate whether potential risks, if any, to benthic invertebrate communities in the LVR adjacent to the Site are statistically different from potential risks to benthic invertebrates in a portion of the LVR upstream of the Site (i.e., the reference reach). Sediment toxicity tests were conducted using a 10-day *Chironomus. dilutus* test for survival, weight, and biomass to represent possible acute effects and a 28-day *Hyalella azteca* test for survival, weight, and biomass to represent possible chronic effects. Hypothesis testing using an analysis of variance (ANOVA; $p < 0.05$) was used to evaluate whether statistical difference existed between the toxicity test results for field samples collected from each of three LVR reaches adjacent to the Site as compared to the LVR upstream reference reach.

Potential risks to benthic macroinvertebrate and fish (aquatic) receptors of the LVR were evaluated using data collected as part of the biological assessment of the LVR. The BAR (Geosyntec 2011b) is included as Appendix RA-E-G3. The assessment was patterned after Illinois water and natural resource agency bioassessment protocols (IDNR 2001, IEPA 2007), which employ multi-metric “index of biotic integrity” (IBI) scoring systems to evaluate stream health. The IEPA considers (along with other factors) the macroinvertebrate index of biotic integrity (mIBI) in conjunction with a fish community index of biotic integrity (fIBI) in making assessments of designated use attainment in streams pursuant to the CWA. If the mIBI is unavailable, the fIBI may be considered along with the Macroinvertebrate Biotic Index (MBI), which is a component of the mIBI, in making preliminary use attainment assessments. In that regulatory context, if a stream attains an mIBI score ≥ 41.8 (or a MBI score ≤ 5.9 , if the mIBI is unavailable) combined with an fIBI score ≥ 41 , the stream would be given a preliminary assessment that it is “Fully Supporting” of aquatic life use in Illinois streams. Under the CWA, IEPA equates the “Fully Supporting” terminology to a conclusion that a stream has “No Impairment” and is indicative of good resource quality (IEPA 2008a). While the biological assessment was undertaken in a different regulatory context (i.e., under CERCLA), comparison of these values derived from the CWA to IBI scores for the river reaches sampled at the Site provides a line of evidence of the overall health of the ecological community in the LVR. Therefore, an mIBI score ≥ 41.8 and an fIBI score ≥ 41 were selected as the BERA metrics for evaluating stream health. The IBIs calculated from the biological assessment data

were also used to evaluate the condition of the communities adjacent to the Site relative to a within stream/same-stream reference reach located upstream in the LVR and away from any potential impacts of the Site. The conditions of the communities adjacent to the Site were also compared to the same-stream reference reach using two biological indices – the Shannon Weiner diversity index (H') and Simpson's Index of Diversity (D_s). The methodology for calculating IBIs and other population metrics are detailed in the BAR.

8.1.2.3 Verification of Field Sampling Design (Step 5)

The primary purpose of Step 5 is to ensure that the data specified by the study design can be collected, and to evaluate whether the specified sampling methods are the most appropriate for addressing the ecological AEs.

Observations made during Phase I and the results of the OU1 site characterization were considered in developing subsequent studies. Prior to mobilization for the Phase II sediment and surface water sampling and biological community assessment, field verification was conducted by Geosyntec and SulTRAC personnel prior to mobilization to ensure that the selected Phase II sampling locations within the LVR were accessible and that the locations were representative of the overall nature of the river. Similarly, prior to sediment sampling for toxicity testing, personnel from Geosyntec, SulTRAC, and US EPA conducted reconnaissance along and within the LVR to jointly investigate sampling locations.

8.1.2.4 Site Investigation and Data Analysis (Step 6)

Field activities related to the toxicity testing and biological community assessments (including biotic tissue collection) are detailed in Section 4.1.4 of Appendix RA and summarized below. Sediment and surface water collection activities for data utilized in the BERA are discussed above in [Section 2.1.3.2](#).

Toxicity testing and biological community assessment activities related to the BERA were conducted in four reaches of the LVR, each a minimum of 330-ft (100-meter); these are:

- Station CAR001 – this sample reach is located at the southern extent of the Slag Pile, approximately 0.10 river mile upstream of the 5th Street (State Route 6) Bridge and adjacent to the southern extent of the OU1 Slag Pile.
- Station CAR002 – located approximately 0.21 river mile upstream of the 5th Street Bridge and adjacent to the OU1 Slag Pile.

- Station CAR003 - located 0.44 river mile upstream of the 5th Street Bridge at the northern end of the OU1 Slag Pile. Though adjacent to the Slag Pile, CAR003 was established to measure the potential effects of the ASO discharges associated with OU2 and the City of LaSalle CSO discharges, both of which discharge to the river within the CAR003 reach.
- Station CAR004 (Reference Reach) – located approximately 2.32 river miles upstream of the 5th Street Bridge and upstream of the Matthiessen and Hegeler Zinc Company Site.

For toxicity testing, sediment samples were collected from the biologically active zone (approximately the top 15 cm of the river) of three depositional areas at CAR002, CAR003, and CAR004 and two depositional areas at CAR001. All sediment was passed through a one-mm stainless steel sieve and homogenized prior to sample collection. Sediment toxicity tests were conducted using a 10-day *C. dilutus* test for survival, weight, and biomass to represent possible acute effects and a 28-day *H. azteca* test for survival, weight, and biomass to represent possible chronic effects. In addition, split sediment samples were analyzed of ammonia, cyanide, nitrogen, metals, PCBs, pesticides, SVOCs (including PAHs), VOCs, TOC, total solids, and grain size. Hypothesis testing using an ANOVA ($p < 0.05$) was used to evaluate whether statistical difference existed between the toxicity test results for field samples collected from each of three LVR reaches adjacent to the Site as compared to the LVR upstream reference reach.

For benthic macroinvertebrate community sampling, each reach was longitudinally divided into east and west halves, generally delineated by the stream thalweg, and sampling was conducted in each half of the four river reaches. Sampling points were evaluated based on habitat proportions for each half reach and sampling (individual jabs) was conducted using a standard long-handled D-frame dipnet (approximately 1-ft frame width) with 500 μ m mesh netting. The samples were shipped to Pennington & Associates, Inc. laboratory for enumeration and taxonomic investigation. The resultant macroinvertebrate community data were evaluated within and between each reach using the multi-metric approaches described in the BERA. As part of the macroinvertebrate community survey, additional effort was targeted towards determining the status of freshwater mussel populations in each sample reach. The freshwater mussel community was surveyed for the presence/absence of mussels at each sample reach via timed searches of one hour conducted by three personnel (total of 3 man-hour surveys). Mussel specimens were investigated in the field and a limited number of common species were collected and processed as part of the upper trophic level wildlife (mammalian and avian) risk characterization.

Fish community sampling was conducted within the full length and width of each sample reach (i.e., split river design was only applicable to the macroinvertebrate samples). The fisheries survey was conducted within wadeable habitats of each reach using a non-electrified seine and a backpack electrofishing unit system. Block nets were established at upstream and downstream reach termini to restrict fish passage and allow for more accurate sampling of fish communities within the reaches. All reaches were sampled for 36 minutes to maintain a consistent sample collection effort within each reach. Electrofishing was conducted in a standardized fashion in a downstream to upstream direction and included all riffle, run, and pool habitats present. A limited number of species were collected and processed as part of the upper trophic level wildlife (mammalian and avian) risk characterization. The resultant aquatic (fish) community data were evaluated within and between reaches using the multi-metric approaches described in the BERA.

8.1.2.5 Risk Characterization (Step 7) and Weight-of Evidence

Step 7, the Risk Characterization, integrates the problem formulation of Step 3, the study design of Step 4, and the data assembled using the evaluation methods described in Steps 5 and 6, to evaluate the potential risk to ecological receptors from exposure to COPECs in environmental media. A detailed description of the risk characterization is presented in Section 4.1.5 of the BERA. This section presents a summary of the ecological risks based on individual lines of evidence (i.e., measurement endpoints) and combines these risk estimates through a process of weighing the evidence to characterize the overall status of the ecological community in the LVR. While the individual lines of evidence are quantitative in nature, the information is combined in a primarily qualitative manner considering the relationship of the measurement endpoint to the AE and the site-specificity of the study design.

The individual elements of the weight-of-evidence analysis are discussed below.

Chemical-Specific Analysis

The BERA began with a refined analysis of COPECs (arsenic, cadmium, copper, lead, mercury, silver, and zinc) that compared location-specific concentrations in sediment and surface water to risk-based effects concentrations (ESVs). ESVs do not take account of site-specific factors, such as possible limited bioavailability of COPECs. For sediment, two ESVs were considered – the TEC and PEC or, if a TEC/PEC was not available, the NOAA ERL and ERM. For surface water, COPEC concentrations were compared to IWQS or, if an IWQS was not available, the Region 5 ESL. This analysis evaluated the

frequency, magnitude, and spatial location (i.e., upgradient, beside, or downgradient of the Site) of exceedances of the ESVs for individual COPECs.

COPECs in sediment exceeded TECs in multiple locations; however, with the exception of cadmium and zinc, the majority of reported COPEC concentrations were below the TEC or within the range of the TEC and PEC values. Cadmium and zinc more frequently exceed their respective PECs than other COPECs. Spatially, the highest COPEC concentrations are associated with samples collected near the outfall of the ASO and CSO, which are immediately upstream of the head of the Slag Pile and immediately upstream of CAR003. Notably, reported COPEC concentrations tended to be higher in the samples collected before 1995, although for certain COPECs (e.g., zinc), comparable concentrations have also been reported in more recent (2007 and 2009) samples.

As part of this refined analysis, site-specific bioavailability data (SEP results) for stream-weathered slag material were also reviewed. BERA COPECs were frequently non-detect in the bioavailable fractions or present at low concentrations relative to other fractions. The bioavailability of cadmium and zinc, the COPECs that most frequently exceeded the TECs/PECs, were estimated to be approximately 27 percent and 1.3 percent, respectively. This conclusion is also supported by the low concentrations of COPECs in the sieved samples analyzed as part of the toxicity testing discussed below. Thus, predicting risks to ecological receptors based solely on exceedances of ESVs, which assume 100 percent bioavailability, almost certainly over-predicts the actual potential for adverse ecological effects.

Relative to media-specific screening criteria, concentrations in surface water were generally lower than concentrations in sediment (i.e., lower ratio of concentration to screening criteria [HQ]). For most COPECs, exceedances of SW ESVs (i.e., IWQS/Region 5 ESL) are primarily limited to samples collected from or adjacent to the ASO and CSO. Zinc, however, exceeds its IWQS at the majority of sampling locations, but even with zinc, the ASO and CSO concentrations are more than two orders of magnitude greater than the average of the remaining samples collected adjacent to the Site. As with sediment ESVs, SW ESVs do not consider site-specific conditions, such as ecological receptors present or water chemistry.

Overall, the refined chemical-specific analysis indicates that COPEC concentrations in both sediment and surface water in some locations exceed risk-based screening criteria. In terms of the weight-of-evidence, the sediment and surface water data are of good quality; however, there are uncertainties associated with the older samples being reflective of current conditions. The sediment concentration data from the 1990s tend to be higher than the more recent (2007 and 2009) concentrations. As a measurement endpoint,

these comparisons may provide a reasonable description of the relative risks of different COPECs to AEs, but are unlikely to reliably predict absolute risks as they are neither site-specific nor receptor-specific. This measurement endpoint is also ranked low in terms of site-specificity relative to the other lines of evidence investigated in the BERA.

Upper Trophic Level Receptors

The effect of concentrations of site-related constituents in the sediment, surface water, and biota of the LVR adjacent to the Site on the survival and reproduction of mammalian and avian populations that feed/forage in the area was evaluated using FCMs that incorporate site-specific biotic and abiotic data.

The BERA FCMs were used to estimate risks to mink and belted kingfisher, which were selected to represent mammalian and avian receptors, respectively. Both the mink and the belted kingfisher were assumed to be exposed to COPECs via incidental ingestion of sediment while foraging, ingestion of surface water as drinking water, and the ingestion of fish and mussels. Specifically, it was assumed that both species' diets were 1) entirely from the LVR (area use factor = 1), 2) consisted only of fish and (undepurated) mussels, and 3) consisted only of biota containing the highest (maximum) tissue concentrations detected in samples collected from the Site area.

For all COPECs, individual NOAEL and LOAEL HQs for the mink were less than 1, indicating that adverse effects to mammalian receptors are unlikely. For the belted kingfisher, the NOAEL HQs were all less than 1 except for mercury (1.4) and zinc (4.4). The sole COPEC for which the individual LOAEL HQ exceeded 1 was zinc (1.7). Although the zinc LOAEL HQ exceeded the BERA threshold of 1, several conservative assumptions in the FCMs may have biased the assumed intake rates high relative to actual field conditions. Conservative assumptions embedded in the models are discussed below.

In terms of the weight-of-evidence, the FCMs ranks moderately in terms of site-specificity. The FCM incorporates site-specific data for concentrations of COPECs in environmental media and biota, but relies on several generic assumptions. For example, the FCMs assume that the investigated species foraged exclusively at the Site and consume fish and invertebrates, represented by mussel tissue samples, with the highest reported COPEC concentrations in Site samples. The FCMs also assume a 100 percent bioavailability for metals from incidental sediment ingestion and from ingestion of undepurated mussel tissue. As noted above in connection with the comparison of sample results to ESVs, SEP analyses demonstrating the presence of COPECs in largely non-bioavailable forms in the slag present in sediments suggest this is a conservative assumption (SEP analysis indicated the bioavailability of zinc is less than 2

percent). Thus, calculated HQs for the mink and belted kingfisher should provide conservative estimates of risks to mammalian and avian species actually observed in the vicinity of the LVR such as, raccoon, beaver, great blue heron, and wood duck.

The BERA FCMs predicted the potential for adverse ecological effects to individual avian receptors; however, given the conservative assumptions embedded in the FCMs, the lack of toxicity predicted for individual mammalian receptors, adverse effects to populations of wildlife receptors who feed/forage along the LVR are unlikely.

Benthic Receptors – Toxicity Testing

Sediment toxicity tests were conducted using a 10-day *C. dilutus* test for survival, weight, and biomass to represent possible acute effects and a 28-day *H. azteca* test for survival, weight, and biomass to represent possible chronic effects. Hypothesis testing using an ANOVA; $p < 0.05$ was used to evaluate if there were statistical differences between the toxicity test results for field samples collected from each of three LVR reaches adjacent to the Site as compared to the LVR upstream reference reach. The reaches are designated CAR001 through CAR004, with CAR004 being the upstream reference reach, CAR003 being located at the northern head of the Slag Pile immediately downstream of the ASO and CSO, CAR002 being located adjacent to the Slag Pile, and CAR001 being located near the southern terminus of the Slag Pile.

In evaluating the results of statistical analyses, an important consideration is the difference between a statistically significant result relative to a control or reference population and a biologically important or ecologically significant difference (US EPA 1997a). A statistically significant difference is a function of both the differences in means and the variability in replicates. The sampling design utilized included highly homogeneous composite samples which should tend to decrease variability and increase the likelihood of detecting differences.

The results of the acute toxicity test using *C. dilutus* showed biological variability typical of these types of assays and variable location specific effects. The results showed no statistically significant difference in survival at CAR001 relative to the reference reach, but a decrease in weight and biomass. A decrease in survival and biomass was observed at CAR002, but there was no significant difference in weight. Notably, decreased survival at CAR002 was only statistically significant with the inclusion of a replicate outlier. Because biomass is a function of survival and weight, this outlier also affected the biomass

calculations. A decrease in survival was observed at CAR003, but there was no significant difference in weight or biomass.

However, the statistical differences identified in the acute toxicity tests have no apparent correlation with chemical concentrations of COPECs observed in the samples for LVR reaches and the reference reach. For example, the concentrations of cadmium were highest in the samples for the reference reach compared to the concentrations measured for the samples adjacent to the Site. And while the reference reach had lower concentrations of zinc than the reaches adjacent to the Site, the concentrations of zinc in samples adjacent to the Site were generally in the same range so that it is difficult to explain why some reaches showed statistically significant differences for some metrics while others did not. Other sediment characteristics, such as bioavailability, could have varied among the toxicity testing samples and contributed to the observed differences in toxicity, however, data was not collected to test this possibility. Because of the extensive homogenization and sieving of the samples prior to analysis we have a high degree of confidence that the chemical concentration results are representative for the actual sediment used in the toxicity testing.

In contrast to the acute test results, the results of the chronic tests showed little evidence of impact. When comparing the reference reach to the Site reaches, no statistically significant effects on *H. azteca* survival or biomass were observed. Effects on weight were spatially limited to one LVR reach and that result was driven by a single sample (LVR608). Overall, the results of the chronic sediment toxicity test support a determination that the Site is not adversely affecting the health of the macroinvertebrate community.

In terms of the weight-of-evidence, the sediment toxicity testing ranks moderate-to-high in terms of site-specificity. The tests utilized Site sediments, but uses naïve (laboratory) organisms. Populations chronically exposed to metals often exhibit enhanced tolerance relative to unexposed or naïve populations through acclimation and/or selection for resistant phenotypes (Kapustka et al. 2003). Given the age of the Site (e.g., the slag pile has been essentially undisturbed for 50 years), it is possible that metal-tolerant species or communities have developed; however, the toxicity tests cannot consider an organism's ability to adapt to metals. Additionally, the test species are selected, in part, based on their sensitivity. Thus, the results of the laboratory toxicity tests are likely conservative measurement endpoints for determining risks to the overall benthic communities of the LVR, which are composed of numerous species of varying sensitivity that may also have adapted to the chemical and physical conditions of the sediment.

Benthic Receptors – Community Assessment

To further assess the condition of macroinvertebrates in the vicinity of the Site, a biological community assessment was conducted. The assessment involved the collection of macroinvertebrate specimens from the various habitats within each of the four reaches. Each reach was longitudinally divided into east and west halves such that potential effects from immediate proximity to the Slag Pile, if any, could be investigated. Results of the community survey in the Site reaches were quantitatively compared to results of the reference reach using multi-metric indices. Two of the indices used were the mIBI, which is currently used by IEPA as a component of assessing compliance with CWA goals, and the MBI, which is currently a component of the mIBI and to some extent a precursor of it. As detailed further in the BAR, the macroinvertebrate sampling method approved and utilized at the Site differed in one aspect from the IEPA sampling protocol, although the comparisons described above were still considered to provide a useful line of evidence. To reduce potential uncertainty related to these differences, comparisons between the reference reach and Site reaches were also made using the Shannon-Weiner and Simpson's diversity indices.

The mIBI scores were variable across the Site; however, all scores reflect a generally healthy and balanced macroinvertebrate community at least comparable in biotic integrity to that expected for Illinois streams (i.e., IEPA Integrity Class 2 or better). Reaches along the middle (CAR002) and southern (CAR001) portion of the Slag Pile had lower mIBI scores and some lower diversity index scores. Conversely, CAR003 (both east and west halves), which is located along the northern edge of the Slag Pile and immediately downstream of the CSO and ASO, had mIBI scores exceeding those for the reference reach and diversity indices that were statistically indistinguishable from the reference reach. The results for the additional analysis conducted using the IEPA (2010) Draft Facility Related Stream Survey and the calculated diversity indices are also supportive of a similar conclusions regarding the macroinvertebrate community in the LVR. Also, the mIBI and other index scores for the west half of the LVR (nearest Site features) were generally similar to, and in many cases better than, those for the east half. So, there is no indication that immediate proximity to the Site features impacted the macroinvertebrate community.

In terms of the weight-of-evidence, the community assessment ranks high for site-specificity. All parameters included in the IBIs and other indices are based on measurements of actual field conditions and the assessment considers multiple species; thus, this measurement endpoint is directly applicable to the AE.

Benthic Receptors – Summary

The macroinvertebrate measurement endpoints can be summarized by Site reach as follows:

- **CAR001:** This reach is located at the southern extent of the Slag Pile, just upstream of State Route 6. COPEC concentrations in sediment and surface water samples in this reach, only some of which were based on 2007 and 2009 data, exceeded some ESVs. In general, the concentrations in this reach were lower than those found in CAR003. Decreases in weight and biomass were observed for *C. dilutus*, but there was no statistically significant difference in survival. Relative to the reference reach, no statistically significant differences in weight, biomass, or survival were observed for the chronic testing using *H. azteca*. The observed differences in the acute toxicity test results cannot be correlated with chemical concentrations because the CAR001 sieved samples had similar chemistry to CAR002 and CAR003 samples and even to the reference reach (except for zinc). Moreover, the observed differences in the acute toxicity tests were not seen in the chronic test making it less likely that the acute results are attributable to Site conditions. In the macroinvertebrate community assessment, macroinvertebrate scores for CAR001 were lower than for the reference reach, as were diversity indices calculated for the east half of the river. Still, the indices were indicative of a healthy and balanced macroinvertebrate community at least comparable in biotic integrity to that expected for similar Illinois streams. Both east and west halves of CAR001 attained mIBI scores greater than 41.8 and MBI scores less than 5.9. Combined with the fIBI results for this reach, the mIBI and MBI values for CAR001 support a preliminary determination that the LVR is “Fully Supporting” of aquatic life use. Overall, while some of the toxicity tests provide conflicting results (reduced growth in acute exposures, but no effects for chronic exposures), the observed differences compared to the reference reach do not seem to be attributable to Site contaminants. And, the more site-specific results of the community assessment suggest the overall macroinvertebrate community is attaining goals for Illinois streams. While some of the measurement endpoints for CAR001 suggest the possibility of limited impacts to the benthic community, those impacts, if any, are not consistently observed and are difficult to attribute to Site contaminants. Any impacts also do not appear to be interfering with the LVR’s ability to attain goals for Illinois streams.
- **CAR002:** This reach is located adjacent to the Slag Pile between CAR001 and CAR003. COPEC concentrations in sediment and surface water samples in this reach exceeded some ESVs,

although some of those exceedances appeared in data collected before 1995. In general, the concentrations in this reach were lower than those found in CAR003. The toxicity tests indicated limited potential for adverse effects. Decreases in survival and biomass (a function of weight and survival) were observed for *C. dilutus*, but the decrease was driven by a single sample – LVR604. Relative to the reference reach, no statistically significant differences in survival, weight, or biomass were observed in the chronic tests using *H. azteca*. As discussed above, *H. azteca* is generally considered a better indicator for measuring effects on survival due to species-specific sensitivity. So given that no effects on survival were observed in the chronic test, it is less likely that the reduced survival in *C. dilutus* is site-related. Further, LVR604 laboratory replicates were highly variable for survival in the acute test. *C. dilutus* survival rates ranged from 0 to 100 percent, with one-half of the replicates exhibiting greater survival than the average of the laboratory control samples. The reduction in biomass observed in the test is primarily a function of the reduced survival in one-half of the replicates. Overall, the toxicity tests support a finding of limited potential for adverse effects. In the community assessment, macroinvertebrate index scores for CAR002 were lower than for the reference reach as were diversity indices calculated for the west half of the river. Still, the indices were indicative of a healthy and balanced macroinvertebrate community at least comparable in biotic integrity to that expected for similar Illinois streams. Both east and west halves of CAR002 attained mIBI scores greater than 41.8 and MBI scores less than 5.9. Similar to CAR001, when combined with the fish biotic integrity index results for this reach, these scores support a preliminary determination that the LVR is “Fully Supporting” of aquatic life use. The limited toxicity observed in the toxicity tests and the attainment of acceptable mIBI and MBI scores support a conclusion that the Site does not appear to be adversely affecting the overall health of the macroinvertebrate community at CAR002.

- **CAR003:** This reach is located at the head of the OU1 Slag Pile and immediately downstream of the ASO and City of LaSalle CSO discharges associated with OU2. COPEC concentrations in sediment and surface water were generally the highest in this vicinity; however, several of the sediment samples were collected in the 1990s and, thus, perhaps are not representative of current conditions. The toxicity tests indicated limited potential for adverse effects. In the acute test, there were no statistically significant differences in weight or biomass, but a decrease in survival was observed for *C. dilutus* (driven by one of the three samples for this reach – LVR607). Relative to the reference reach, a decrease in weight was observed for *H. azteca* (also driven by one sample – LVR608), but there was no statistically significant difference in survival or biomass. *H. azteca* is generally considered a better indicator for measuring effects on survival

due to species-specific sensitivity to metals. Given that no effects on survival were observed in the chronic test (and in particular no effects on survival in the same sample that showed lower survival in the acute test), it is less likely that the reduced survival in *C. dilutus* is site-related. The limited/lack of toxicity observed in the toxicity tests was further supported by the community assessments. CAR003 attained mIBI scores greater than 41.8 and MBIs less than 5.9 in both east and west reaches. Further, the mIBIs in the east and west halves of CAR003 actually exceeded their respective mIBIs in the reference reach and the diversity indices (i.e., H' and D_s) indicated a healthy and balanced macroinvertebrate community. Those scores, when combined with the fIBI results for this reach support a preliminary determination that the LVR is “Fully Supporting” of aquatic life use. Thus, the Site does not appear to be adversely affecting the overall health of the macroinvertebrate community at CAR003.

Aquatic (Fish) Receptors

The biotic integrity of the fish community based on the fIBI scoring indicates that all LVR reaches sampled, including the reference reach, are in IEPA Integrity Class 3 (lower biotic integrity than expected for typical Illinois reference streams) and are ecologically similar. The fIBI scores obtained for each LVR reach were in a narrow range of two points, and all reaches, including the three adjacent to the Site, had scores greater than 41. The combination of these fIBI scores and the mIBI (and MBI) scores for each reach support a preliminary determination that the LVR is “Fully Supporting” of aquatic life use in Illinois streams according to IEPA guidance. Thus, it is reasonable to conclude that the ecological condition of the fish community in the LVR adjacent to the Site is not meaningfully different from the “background” conditions as measured at the same-stream reference reach. The calculated Shannon-Weiner and Simpson’s diversity indices in the LVR are supportive of a similar conclusion.

In terms of the weight-of-evidence, the community assessment ranks high in terms of site-specificity. All parameters included in the metrics are based on measurements of actual field conditions and the assessment considers multiple species; thus, this measurement endpoint is directly applicable to the AE. Further, the multi-metric based protocol provides a sound, ecologically-based framework and proven tool for comparing the biological integrity of communities from like habitats in a study area.

8.1.2.6 BERA Summary and Conclusions

In accordance with US EPA guidance, the BERA combined each line of evidence (measurement endpoint results) through a process of weighing the evidence to characterize the overall status of the ecological

community in the LVR. Based on the weight-of-evidence, the BERA supports the following specific conclusions:

No unacceptable risks were interpreted for mammalian receptors (represented by the mink) for exposure to sediment, surface water, and biota of the LVR. LOAEL HQs were less than 1 for all COPECs evaluated in the BERA.

The FCM for the belted kingfisher resulted in a LOAEL HQ of 1.7 for zinc, which under the BERA methodology indicates a potential for adverse effects to the growth and reproduction of avian receptors that feed/forage in the LVR adjacent to the Site. Calculated risks to the belted kingfisher were primarily driven by ingestion of zinc in invertebrates, represented by mussel tissue samples; however, due to the uncertainties described previously (e.g., assumption of a diet consisting exclusively of fish and invertebrates from the Site, use of undepurated samples, use of the maximum field-measured biota concentrations, and use of laboratory-based effects estimates [TRVs]), this risk estimate is may be biased high.

The BERA FCMs predicted the potential for adverse ecological effects to individual avian receptors; however, given the conservative assumptions in the FCMs (exposure and effects estimates) and the lack of toxicity predicted for individual mammalian receptors, it is unlikely that the Site is adversely affecting populations of upper trophic level receptors that feed/forage along the LVR adjacent to the Site.

The toxicity testing results combined with the more site-specific biological community assessment and resulting mIBI metrics indicated the benthic macroinvertebrate community was functioning and viable. The results of the acute toxicity testing using *C. dilutus* indicated that sediments at CAR001 may adversely affect the growth of macroinvertebrates; however, other site-related acute effects to the health of the macroinvertebrate community were not apparent. No statistically significant chronic effects on *H. azteca* survival or biomass were observed, and effects on weight were spatially limited and not co-located with effects observed in the acute test. The observed differences in the acute toxicity test results also cannot be correlated with chemical concentrations in Site sediments or surface water. In the macroinvertebrate community assessment, indices were indicative of a healthy and balanced macroinvertebrate community at least comparable in biotic integrity to that expected for similar Illinois streams. Specifically, both east and west halves of the Site reaches attained mIBI scores ≥ 41.8 and MBI scores ≤ 5.9 , which were established as BERA metrics for investigating potential risks to benthic macroinvertebrate communities.

The biological community assessment and resulting fIBI metrics indicated the aquatic (fish) community is functioning and viable. The fIBI scoring from the fish community assessment indicates that all LVR reaches sampled, including the reference reach, are in IEPA Integrity Class 3 and scored in a very narrow range. Thus, it is reasonable to conclude that the ecological condition of the fish community in the LVR adjacent to the Site is not meaningfully different from the “background” conditions as measured at the same-stream reference reach. Further, all fIBI scores were ≥ 41 , which was established as a BERA metric for investigating potential risks to aquatic (fish) communities.

The IEPA considers (along with other factors) the mIBI (or MBI) in conjunction with a fIBI in making assessments of designated use attainment in streams pursuant to the CWA. In that regulatory context, if a stream attains an mIBI score of ≥ 41.8 (or a MBI score ≤ 5.9 , if the mIBI is unavailable) combined with an fIBI score of ≥ 41 , the stream would be given a preliminary assessment that it is “Fully Supporting” of aquatic life use in Illinois streams. Under the CWA, IEPA equates the “Fully Supporting” terminology to a conclusion that a stream has “No Impairment” and is indicative of good resource quality (IEPA 2008a). While the BERA was conducted in a different regulatory context (i.e., under CERCLA), attainment of these values in all the Site reaches provides a line of evidence of the overall health of ecological community in the LVR.

Together, these lines of evidence provide support that the Site is not having a significant adverse effect on the overall health of the ecological community of the LVR. As indicated in the bullets above, some measurement endpoints suggest the possibility of limited impacts to the benthic community, but those effects, if any, are not consistently observed (e.g., no effects in the chronic toxicity tests) and are difficult to attribute to Site contaminants. The BERA methodology also calculated potential risks to current avian receptors; however, given the conservative assumptions and uncertainties associated with these risk estimates and lack of risks to mammalian receptors, risks to local populations of upper trophic level wildlife receptors are not anticipated. Thus, although the presence of slag material and municipal/industrial discharges in the vicinity of the sample reaches has the potential to affect ecological receptors in the LVR, the results of the BERA indicate the contrary. Risk management actions to reduce on-going contributions of contaminants from Site features to the LVR (e.g., erosion and storm water runoff control for the Slag Pile and control of inputs from the ASO) would further reduce chemical concentrations and, thus, further mitigate potential ecological risks.

8.2 OU2 ECOLOGICAL RISK ASSESSMENT

Consistent with US EPA ERA guidance (US EPA 1997a), a SLERA and a BERA were conducted for the upland area of OU2. The following sections provide a summary and conclusions for the SLERA and BERA.

8.2.1 OU2 Screening Level Risk Assessment

The first step in the SLERA is to investigate the habitats present at OU2. In October 2007, SulTRAC conducted a habitat evaluation of OU2 to gather data necessary to investigate potential ecological receptors and develop a CSM for the ERA to be conducted for OU2 (see “Ecological Habitat Evaluation, Matthiessen and Hegeler Zinc Company, LaSalle County, Illinois OU2, Technical Memorandum, Internal Draft,” presented in Appendix S-5). SulTRAC investigated the following four habitat types shown in Figure RA-E-S2 in Appendix RA: 1) main plant area - highly disturbed (little or no vegetation); 2) disturbed with vegetation (woodland-grassland), adjacent to the main plant area; 3) savannah; and 4) oak-hickory woodland. A riverine habitat next to OU2 is included as part of OU1.

Based on information on the habitats present and known areas of contamination, an ecological CSM was prepared that investigates likely categories of receptors with anticipated complete exposure pathways. The ecological CSM also investigates AEs for the ecological evaluation. The first two elements of the CSM – sources of contamination and types of habitats have been discussed above. Potential exposure points, exposure routes, and ecological receptors at the Site are discussed in the following paragraphs. Appendix RA-E-S3 presents a diagram of the OU2 CSM.

The focus of the ERA for OU2 is soils only in the four habitats investigated: highly disturbed, disturbed with vegetation, savannah, and oak-hickory woodland. Small depressions that may collect water are considered temporary water bodies and are not anticipated to provide suitable habitat for an aquatic community.

During the ecological habitat characterization, a variety of receptors were observed at OU2, and other receptors, although not observed directly, are likely present. These include plants, soil invertebrates, birds, and mammals in the terrestrial portions of OU2. Individual species are not evaluated in the SLERA. However, potentially complete exposure pathways are evaluated for general receptor categories.

As noted above, the SLERA for OU2 focuses on soil as the main impacted medium. Therefore, the AEs focus on terrestrial receptors at OU2.

The specific AEs evaluated in the OU2 SLERA are as follows:

- Ensure adequate protection of terrestrial plant and soil invertebrate communities, including native plant communities
- Ensure adequate protection of mammalian and avian populations
- Ensure adequate protection of threatened and endangered species (including candidate species) and species of special concern and their habitats

The final component of Step 1 is the screening level ecological effects evaluation, which investigates threshold exposure concentrations for constituents in environmental media below which adverse effects are not expected to occur. These highly conservative constituent concentrations are unlikely to result in adverse ecological effects even to the most sensitive ecological receptors. In Step 2, these values are used as bases to evaluate if adverse ecological effects could result from exposure to constituents in environmental media.

The endpoint measures for the terrestrial communities at OU2 were selected from a hierarchy of sources taking into account confidence in the scientific basis for the SVs. Values selected were the lowest for the four major exposed groups investigated in the documents reviewed — plants, soil invertebrates, mammals, and birds. This hierarchical approach provides conservative soil ESVs to estimate potential ecological risks.

Maximum concentrations (EPCs) of constituents detected in each ecological exposure medium and EA were compared to the conservative ESVs investigated in Step 1. The comparison resulted in a HQ. When a constituent's HQ exceeds 1, the constituent is considered present at a concentration exceeding its threshold concentration. However, this exceedance does not imply occurrence of adverse effects but only a potential for adverse effects.

The SLERA results identify potential unacceptable risks to ecological receptors in all areas sampled. The following sections discuss the SLERA results and significant risk drivers and presents conclusions and recommendations based on the SLERA results.

8.2.1.1 Main Plant Area – Highly Disturbed Habitat

The SLERA for the Main Plant Area, highly disturbed habitat, investigates 44 COPECs with respective HQs exceeding 1 based on maximum concentrations. Of the major groups of contaminants investigated in soils in the area, metals have the highest HQs. The metals with the highest HQs are the following:

- Lead (19,000)
- Zinc (4,740)
- Antimony (2,410)
- Cadmium (2,830)
- Mercury (1,540)
- Selenium (1,010)

The organic constituents with highest HQs in this habitat include Aroclor-1260 (566), naphthalene (85.5), and Aroclor-1248 (39.1). The soils in this area pose a potentially significant risk to ecological receptors, and metals are the major risk drivers. However, based on the limited habit value of the Main Plant Area, lack of vegetation over this area, and high levels of contamination observed in this area, it is recommended that risks associated with this area not be further evaluated as part of the BERA.

8.2.1.2 Next to the Main Plant Area – Disturbed with Vegetation Habitat

The SLERA for the area next to the Main Plant Area, disturbed habitat with vegetation, investigates 39 COPECs with respective HQs exceeding 1 based on maximum concentrations. Of the major groups of contaminants investigated in the soils in the area, metals have the highest HQs. The metals with the highest HQs are the following:

- Lead (3,060)
- Antimony (2,440)
- Zinc (2,180)
- Mercury (949)
- Cadmium (815)

The organic constituents with highest HQs in this habitat include naphthalene (201), 2,4-dimethylphenol (75), and benzo(a)pyrene (30.3). The soils in this area pose a potentially significant risk to ecological receptors, and metals are the major risk drivers. It is recommended that risks associated with this area be further evaluated as part of the BERA.

8.2.1.3 Savannah Habitat

The SLERA for the savannah habitat investigates 27 COPECs with respective HQs exceeding 1 based on maximum concentrations. Of the major groups of contaminants investigated in the soils in the area, metals have the highest HQs. The metals with the highest HQs are the following:

- Zinc (2,850)
- Cadmium (806)
- Lead (672)
- Iron (398)
- Aluminum (340)

The organic constituents with highest HQs in this habitat include 2,4-dimethylphenol (75), naphthalene (62.4), and benzo(a)pyrene (10.4). The soils in this area pose a potentially significant risk to ecological receptors, and metals are the major risk drivers. It is recommended that risks associated with this area be further evaluated as part of the BERA.

8.2.1.4 Oak-Hickory Woodland Habitat

The SLERA for the oak-hickory woodland habitat investigates 17 COPECs with respective HQs exceeding 1 based on maximum concentrations. Of the major groups of contaminants investigated in the soils in the area, metals have the highest HQs. The metals with the highest HQs are the following:

- Aluminum (610)
- Cadmium (600)
- Zinc (596)
- Iron (238)
- Lead (212)

The only organic constituent with an HQ exceeding 1 is methoxychlor (1.9). The soils in this area pose a potentially significant risk to ecological receptors, and metals are the major risk drivers. It is recommended that risks associated with this area be further evaluated as part of the BERA.

8.2.1.5 Area East of the Little Vermilion River

The SLERA results for the savannah habitat in the area east of the LVR investigates 16 COPECs with respective HQs exceeding 1 based on maximum concentrations. The surface soil samples from this area were analyzed for metals only. Therefore, only metals results were compared to the ESVs. The metals with the highest HQs are the following:

- Selenium (4,620)
- Cadmium (1,300)

- Zinc (1,120)
- Aluminum (260)
- Iron (161)
- Lead (145)

The soils in this area pose a potentially significant risk to ecological receptors, and metals are the major risk drivers. However, because this area is not part of OU2 and because of the limited data available for this area, it is recommended that risks associated with this area not be further evaluated as part of the BERA.

8.2.1.6 Conclusions and Recommendations

The results from the SLERA for the upland portion of OU2 show that most portions of OU2 contain metals, pesticides, PCBs, and PAHs at concentrations that may pose potentially unacceptable risks to ecological receptors. Based on this information, a BERA is recommended for the area adjacent to the Main Plant Area, disturbed with vegetation habitat; the savannah habitats and the oak-hickory woodland habitat.

8.2.2 OU2 Baseline Risk Assessment

The focus of the BERA for OU2 is to describe the likelihood, nature, and extent of adverse effects to upland ecological receptors resulting from exposure to contaminants released to the environment from past or present activities at OU2. The BERA follows the various steps outlined in US EPA's ERA guidance for problem formulation, measurement endpoints, study design, data evaluation, and risk characterization (US EPA 1997a).

The ecological receptors evaluated in the SLERA include terrestrial receptors (plants, soil invertebrates, mammals, and birds) that could contact surface soil at each of the four investigated habitats in the upland portions of OU2. After discussion with US EPA and other stakeholders, it was decided to focus the BERA on habitats with the highest ecological value. The Main Plant Area of OU2 is not included in the BERA as a significant EA. Therefore, the BERA focuses on potential impacts to ecological receptors in the three habitats of highest quality at OU2: the area adjacent to the main plant disturbed with vegetation (woodland and grasses), savannah, and oak hickory woodland.

The next step is to evaluate whether it is appropriate for the BERA to focus on a reduced number of COPECs. Only COPECs evaluated as posing potential risks and present at concentrations exceeding background concentrations are carried forward in the BERA.

Part of the next phase of the problem formulation is to review the CSM based on site-specific conditions. Figure RA-E-S3 in Appendix RA presents the CSM as part of the SLERA. Based on the information obtained from the SLERA, no exposure pathways or general receptors can be removed from the original CSM, so the CSM remains unchanged. The exposure pathways evaluated in the BERA are summarized below.

- Plants and Soil Invertebrates: The primary exposure pathway for both terrestrial plants and soil invertebrates is direct contact with contaminated soils.
- Birds and Mammals: Birds and mammals may be exposed through ingestion of surface water, soils, and dietary items. The BERA quantitatively evaluates a variety of avian and mammalian receptors. This evaluation also incorporates site-specific information obtained for plants and soil invertebrates, other tissue data, and soil contaminant levels.

The AEs investigated in the SLERA are further refined to focus on specific portions of the terrestrial ecosystem at OU2. The BERA endpoints focus on specific exposure pathways for a variety of receptors. In the upland terrestrial portions of OU2, these endpoints include protection of the following:

- Terrestrial plant community function and viability
- Soil invertebrate community function and viability
- Herbivorous mammalian community function and viability
- Invertivorous mammalian community function and viability
- Omnivorous mammalian community function and viability
- Carnivorous mammalian community function and viability
- Herbivorous avian community function and viability
- Invertivorous avian community function and viability
- Omnivorous avian community function and viability
- Carnivorous avian community function and viability

Measurement endpoints define the measures used to quantify and predict attainment of AEs.

Measurement endpoints are measures of adverse effects on ecological receptors in response to a stressor.

Measures of ecosystem characteristics influence behaviors and locations of ecological receptors, distribution of stressors, and life-history characteristics of ecological receptors that may affect exposure or response to the stressor (US EPA 1997a).

A brief discussion of the measurement endpoints used for the BERA is provided below.

- Plants – comparison of soil and sediment COPEC concentrations to ecotoxicity SVs: Concentrations of COPECs in soil are compared to SVs for plants. HQs are developed by dividing the 95 percent UCL by the plant SV. In addition, the toxicity of a limited number of soil samples is evaluated with a seed germination and root and shoot elongation test.
- Terrestrial macroinvertebrates – comparison of soil COPEC concentrations to ecotoxicity benchmarks: Concentrations of COPECs in soil are compared to soil invertebrate SVs. HQs are developed by dividing the 95 percent UCL by the invertebrate SV. Potential risk is indicated when the concentration of a COPEC in soil exceeds the SV.
- Mammalian receptors – reproductive or physiological effects to meadow vole, short-tailed shrew, deer mouse, raccoon, and red fox: The meadow vole is used as a surrogate for herbivorous mammal populations, the short-tailed shrew for invertivorous mammal populations, the deer mouse and raccoon for omnivorous mammal populations, and the red fox for carnivorous mammal populations at OU2. A conservative daily dose is calculated based on a COPEC's EPC and average natural history parameters for these mammals. HQs are developed by dividing the daily dose for each COPEC by the appropriate literature-derived TRV.
- Avian consumers – reproductive or physiological effects to the northern bobwhite, marsh wren, American robin, and American kestrel: The northern bobwhite is used as a surrogate to represent herbivorous bird populations, the marsh wren to represent soil invertebrate-consuming bird populations, the American robin to represent omnivorous bird populations, and the American kestrel to represent carnivorous bird populations at OU2. A conservative daily dose is calculated based on a COPEC's EPC and average natural history parameters. HQs are developed by dividing the estimated daily dose for each COPEC by the appropriate literature-derived TRV.

The evaluation of potential risks to plants and soil invertebrates is based on comparison of soil EPCs to plant and soil invertebrate-specific ESVs. The evaluation of risks to birds and mammals is based on the selected assessment and measurement endpoints investigated in Section 4.2.1.1 in Appendix RA. FCMs are used to assess exposure of birds and mammals to chemicals ingested in food or incidentally during other activities, especially chemicals that bioaccumulate (Pascoe et al. 1996).

The FCMs for birds and mammals assume that exposure to a COPEC is primarily through ingestion of contaminated sediment and prey. Exposure is assessed within the context of the following linear food chains to evaluate potential ecological effects on birds and mammals that consume plants, soil invertebrates, and aquatic organisms:

- Soils → Plants → Meadow vole
- Soils → Plants and Soil Invertebrates → Short-tailed shrew
- Soils → Plants and Soil Invertebrates → Deer mouse
- Soils → Plants, Mammals, and Aquatic Life → Raccoon
- Soils → Plants and Mammals → Red fox
- Soils → Plants and Soil Invertebrates → Northern bobwhite
- Soils → Soil Invertebrates → Marsh wren
- Soils → Plants and Soil Invertebrates → American robin
- Soils → Animals → American kestrel

Site-specific bioaccumulation factors for metals are calculated for both plants and soil invertebrates for each habitat. These bioaccumulation factors are based on measurements of soil metal concentrations and collocated vegetation or soil invertebrate concentrations. The bioaccumulation factors for the organic constituents investigated in the soils and the mammal bioaccumulation factors are based on literature values.

TRVs used in the FCMs primarily are from US EPA's Ecological SSL documents (US EPA 2005) and US EPA Region 9 Biological Technical Assistance Group (BTAG)-Recommended TRVs for Mammals and Birds (US EPA 2002b, 2009g). Each TRV represents a critical exposure level from a toxicological study and is supported by a data set of toxicological exposures and effects. A low TRV is a conservative value consistent with a chronic NOAEL. A high TRV represents a mid-range effect level for a COPEC at which the endpoint of toxicity is ecologically relevant. A high TRV is a value consistent with a chronic LOAEL.

The BERA risk characterization process integrates information from the exposure and effects assessments to evaluate relationships among chemicals and adverse effects on organisms. This integration relies on site-specific chemical analytical data, selection of COPECs, site-specific bioaccumulation information, FCMs, and available scientific literature. The BERA attempts to use as many site-specific assumptions as possible to make the assessment reflect site conditions.

Adequate information is available to evaluate the potential risk to receptors from chemicals in all habitats at OU2 despite the sources of uncertainty described in Section 4.2.5 in Appendix RA. The BERA indicates that potentially significant ecological risk exists at the three habitats evaluated at OU2 based on evaluation of EPCs of chemicals using site-specific exposure assumptions when available and conservative assumptions when site-specific information is not available. The following sections summarize the risks to ecological receptors at each of the three habitat areas evaluated as part of the BERA. For the purposes of this section, “most of the risk” for each receptor in each habitat is presumed to be attributable to COPECs with the highest HQs for that receptor in that habitat.

8.2.2.1 Next to the Main Plant Area – Disturbed with Vegetation

The habitat next to the Main Plant Area is characterized by a variety of secondary growth vegetation. The habitat is of marginal quality and has been impacted by disposal of a variety of waste materials from smelting and related activities. This habitat is characterized by high levels of metals contamination and lower levels of organic contaminants, including pesticides, PCBs, and PAHs. The BERA identifies significant risks to all receptor communities. Metals are the predominant risk drivers for this habitat. For the lower trophic levels, the major risk drivers are chromium, lead, mercury, selenium, and zinc. For mammalian receptors, the major common risk drivers are antimony and selenium. For avian receptors, the major common risk drivers are lead, mercury, selenium, and zinc.

The number of risk drivers and severity of impacts decrease with higher trophic level receptors, likely because of limited bioaccumulation of metals at the Site in vegetation and soil invertebrates and because of limited movement up the food chain. The lettuce seed germination tests and root and shoot elongation tests show significant impacts from the soils in this habitat. The earthworm bioaccumulation tests using soils from this habitat also revealed soil toxicity. These results indicate direct toxicity associated with these soils. Most of the risks associated with this habitat are from a limited number of metals investigated in soils and accumulation of metals in plants, soil invertebrates, and higher trophic-level mammals.

8.2.2.2 Savannah

The savannah habitat is characterized by open grassland areas in the northern portion of OU2. The habitat is of fair quality and limited size and has been impacted by disposal of a variety of waste materials from smelting and related activities. This habitat is characterized by high levels of metals contamination and limited levels of organic contaminants, including pesticides, PCBs, and PAHs. The BERA identifies significant risks to all receptor communities except raccoons and red foxes. Metals are the predominant

major risk drivers for this habitat. For the lower trophic levels, the major risk drivers are aluminum, chromium, lead, and zinc. For the mammalian and avian receptors, the major common risk driver is zinc.

The number of risk drivers and severity of impacts decrease with higher trophic level receptors, likely because of limited bioaccumulation of metals at the Site in vegetation and soil invertebrates and because of limited movement up the food chain. The lettuce seed germination tests and root and shoot elongation tests indicate significant impacts from soils in this habitat. The earthworm bioaccumulation tests using soils from this habitat also revealed soil toxicity. These results indicate direct toxicity associated with these soils. Most of the risks associated with this habitat are from a limited number of metals investigated in soils and accumulation of metals in plants, soil invertebrates, and higher trophic-level mammals.

8.2.2.3 Oak-Hickory Woodland

The oak-hickory woodland habitat is a good quality habitat dominated by oak and hickory woodland and a variety of understory shrubs and other plants. The habitat is located next to the LVR and is part of the flood plain. This habitat is characterized by metals contamination at concentrations lower than those in the other two habitats and very limited levels of organic contaminants, including pesticides, PCBs, and PAHs. The BERA identifies significant risks to all receptor communities except meadow voles, deer mice, raccoons, and red foxes. Metals are the only major risk drivers within this habitat. For the lower trophic levels, the major risk drivers are aluminum, chromium, mercury, and zinc. For mammalian receptors and avian receptors, the major common risk driver is zinc.

The number of risk drivers and severity of impacts decrease with higher trophic level receptors, likely because of limited bioaccumulation of metals at the Site in vegetation and soil invertebrates and because of limited movement up the food chain. The lettuce seed root and shoot elongation tests show significant impacts from soils in this habitat. The earthworm bioaccumulation tests using soils from this habitat also revealed soil toxicity. These results indicate direct toxicity associated with these soils. Most of the risks associated with this habitat are from a limited number of metals investigated in soils and accumulation of metals in plants, soil invertebrates, and higher trophic-level mammals.

9.0 SUMMARY AND CONCLUSIONS

This section provides a summary of the major findings of the RI, including nature and extent of contamination, contaminant fate and transport, and risk assessment. Further, this section presents conclusions regarding data limitations and recommended future work. The following sections present the OU1 summary ([Section 9.1](#)), the OU2 summary ([Section 9.2](#)), the HHRA summary ([Section 9.3](#)), the ERA summary ([Section 9.4](#)), and conclusions drawn based on RI findings ([Section 9.5](#)).

9.1 OU1 SUMMARY

The following sections summarize the nature and extent of contamination and the contaminant fate and transport at OU1. Detailed descriptions and analyses of the nature and extent of contamination in OU1 are presented in [Section 4.1](#) of this report. Descriptions of the fate and transport of the evaluated contaminants are presented in [Section 5.4](#) of this report.

9.1.1 Nature and Extent of Contamination

The nature and extent of contamination at OU1 is fully described in [Section 4.1](#) of this report. Soils, slag, groundwater, surface water, sediment, and air were sampled as part of the RI between summer of 2007 and summer of 2009. Extensive multi-media sampling was conducted prior to the RI on OU1 from 1991 through 1994 as described in [Section 1.2.3.1](#) of the RI report. The data collected prior to the RI was included in [Section 4.1](#) and has been considered in the OU1 discussions regarding nature and extent. For the purposes of the RI, OU1 has been adequately delineated both horizontally and vertically in all media.

Primary contaminants of interest were found in soil, groundwater, surface water, and sediments. The contaminants of interest most frequently found are metals, with less frequent exceedances of screening levels measured in SVOCs, VOCs, PCBs, and pesticides. The primary contaminants of interest were observed in the Plant Area, in the LVR, and in the Slag Pile Area.

The primary contaminants of interest in surface and subsurface soil samples are metals and to a lesser extent, SVOCs and PCBs. The number of screening level exceedances and their horizontal and vertical distribution for SVOCs and PCBs is less than for metals. In addition, several, though not all of the SVOC and PCB exceedances are from samples collected in the early 1990's. In the Plant Area, analytical results generally indicate that surface soils (i.e., 0 to 2 ft bgs) contain higher contaminant concentrations and a greater extent of contamination when compared to subsurface samples (i.e., > 2 ft bgs). Contaminants of interest in the Plant Area are limited to metals, SVOCs, and PCBs (a single pre-1994 sample) in the

surface soils, with only metals detected above the screening levels in subsurface soils. In the Slag Pile, both metals and SVOCs were present in both surface and subsurface samples above screening levels, in one case to a depth of 109 ft bgs.

The primary contaminants of interest in groundwater samples are metals and to a limited extent, VOCs and SVOCs. Impacted groundwater was evident in both WBZ1 and WBZ2. Contaminants of interest in the groundwater samples collected in the Plant Area were metals, two VOCs (in a single sample), and one SVOC (also in a single sample). Contaminants of interest in the groundwater samples collected from the Slag Pile were limited to metals. Contaminants of interest in surface water samples collected from the LVR were metals and cyanide.

Contaminants of interest in the sediment samples collected from the LVR were metals, one VOC (acetone, which could be laboratory artifact), SVOCs (mostly from pre-1994 samples), PCBs (all from pre-1994 samples), and pesticides (also all from pre-1994 samples). Contaminants of interest from Slag Pile sediment samples included metals and SVOCs, two PCB aroclors, and acetone, a VOC which may be a laboratory artifact.

9.1.2 Contaminant Fate and Transport

The contamination found on OU1 was present in soil in both surface and subsurface samples, surface water (total and dissolved), groundwater (total and dissolved), and sediment samples from the LVR and the Slag Pile. Air sampling was limited to samples collected during the test trenching to delineate the limits of the Slag Pile, in accordance with the approved Work Plan. No airborne contamination was observed during the investigation of OU1.

The contaminants of interest detected in soil/solids from OU1 in excess of SVs were metals, SVOCs, and PCBs. The contaminants present in the soils can be transported by a variety of means. Contaminants present in soils/solids may tend to absorb to soil particulates and organic matter and may be transported by several processes, including physical transport by surface water runoff, physical transport by dust migration, volatilization, and leaching deeper into subsurface soil. A likely migration route for these contaminants is from soil to groundwater through erosion and transport in surface water. Other than fugitive dust generation, migration of these contaminants to air through volatilization is not significant because the contaminants most frequently detected at concentrations exceeding the screening levels are inorganic and are not volatile (with the possible exception of mercury, if present in elemental form,

though that is not expected). However, as noted above, airborne contamination was not observed during the investigation of OU1.

The contaminants of interest detected in groundwater from OU1 in excess of SVs were metals, VOCs, and one SVOC. Many factors influence the rate of contaminant movement in an aquifer system, including the physiochemical properties of the contaminants (such as solubility, density, viscosity, etc.) and the physiochemical properties of the environment (such as soil permeability, porosity, bulk density, particle size distribution, groundwater and soil/sediment geochemical conditions, soil mineralogy, speciation, extent and connectivity of fractures, etc.). Because all these factors can affect the rate of contaminant movement through aquifers, it can be very difficult to predict such movement. Groundwater gradients in both WBZ1 and WBZ2 indicated lateral movement of groundwater generally to the east, toward the LVR. Evidence of vertical gradients from the bedrock into the overlying alluvial sediments was noted where nested wells were present in the Slag Pile Area. Less evident is the likely flow of groundwater from WBZ2 at the bluff face into the Slag Pile, WBZ1, which covers the slope. As groundwater discharges into surface water, changes in the physiochemical nature of the water may also result in precipitation of dissolved compounds, potentially producing sediments with elevated contaminant levels.

The contaminants of interest detected in surface water collected from the LVR in OU1 in excess of SVs were only metals. Metals were observed in both total and dissolved analyses, indicating the contamination was being transported both as a dissolved fraction and as suspended solids in the LVR. The suspended solids may be re-deposited as sediments, just as the sediments may be remobilized and transported with the surface water. To some limited extent, the surface water may also be introduced as recharging groundwater into the banks of the river under certain high water events.

The contaminants of interest detected in the sediments were primarily metals and to a lesser extent, VOCs, SVOCs, PCBs, and pesticides. Contaminated sediments in the LVR may be picked up by surface water and transported downstream as suspended sediments before they are re-deposited. As with soils, soluble contaminants within the sediments may become dissolved within the surface water or migrate to the groundwater.

9.2 OU2 SUMMARY

The following sections summarize the nature and extent of contamination and the contaminant fate and transport at OU2. [Section 4.2](#) presents additional details regarding the nature and extent of contamination at OU2, and [Section 5.5](#) presents details regarding contaminant fate and transport at OU2.

9.2.1 Nature and Extent of Contamination

[Section 4.2](#) and Table 4.3.2-1 fully describe the nature and extent of contamination at OU2. Soils, building materials, piles, groundwater, surface water, and air were sampled between Summer 2007 and Winter 2010. For the purposes of the RI, the nature and extent of contamination at OU2 is considered to have been adequately delineated both vertically and horizontally in soils, groundwater, and surface water. The nature and extent of contamination in piles and building materials is considered to have been adequately delineated in terms of the original goal of obtaining disposal information for future remediation options.

The primary contaminants of interest in surface and subsurface soil samples are metals, PAHs, PCBs, and asbestos. In general, analytical results indicate that surface soil contains higher contaminant concentrations and a greater extent of contamination than subsurface soil. One location near the Rolling Mill contains cVOCs at concentrations exceeding the screening criteria, and this location aligns with the cVOCs detected at concentrations exceeding the screening criteria in groundwater.

The primary contaminants of interest in building material and pile samples are metals, PAHs, PCBs, and asbestos. PAHs primarily were detected at concentrations exceeding the screening criteria in building material samples composed of wood. Asbestos was detected in building material samples composed of brick and concrete, which suggests that the asbestos may be embedded in the manufactured material matrix. PCB analytical detections were spread across the former main industrial area for both building material and pile samples.

The primary contaminants of interest in groundwater samples are metals, PAHs, and VOCs. Samples from WBZ1 wells in OU2 contained higher concentrations of contaminants, primarily metals, than samples from WBZ2 wells. WBZ1 wells primarily are screened at shallow depths and therefore have a greater connection to surface soil contamination and surface discharges. The highest metal concentrations in groundwater were detected in samples from WBZ1 wells in the former main industrial area of OU2. Some VOCs were detected in OU2 groundwater near the Rolling Mill building along the southern

boundary of OU2. PAHs were detected near the former ASTs in MW-10 northeast of Building 100. For both VOCs and PAHs, detections were localized.

The primary contaminants of interest in surface water samples are arsenic, cadmium, lead, mercury, and zinc. Most of the samples with contaminant levels exceeding the SWSVs were collected from the central portion of OU2, which was the former main industrial area. The sampling locations in this area are at a low elevation in an area fed by surface water runoff and subsurface preferential pathways that discharge into the low-lying area.

9.2.2 Contaminant Fate and Transport

The contaminants of interest detected in soil and solid samples collected at OU2 at concentrations exceeding the SVs include metals, VOCs, SVOCs, PCBs, pesticides, and asbestos. Contaminants in soils and solids may tend to adsorb to soil particulates and organic matter and may be transported by several processes, including physical transport by surface water runoff (including transport into subsurface drainage-ways such as old sewers), physical transport by dust migration, volatilization, and leaching into deeper subsurface soil. A likely migration route for these contaminants is from soil to groundwater through erosion and transport in surface water. Other than fugitive dust generation, migration of these contaminants to air through volatilization is considered not significant because the contaminants most frequently detected at concentrations exceeding the RSLs are inorganic contaminants that are not volatile (except for mercury).

The contaminants of interest detected in groundwater at OU2 at concentrations exceeding the GWSVs included metals (total and dissolved), VOCs, SVOCs, and pesticides. Many factors influence the rate of contaminant movement in an aquifer system, including the physiochemical properties of the contaminants (such as solubility, density, viscosity, etc.) and the physiochemical properties of the environment (such as soil permeability, porosity, bulk density, particle size distribution, groundwater and soil/sediment geochemical conditions, soil mineralogy, speciation, extent and connectivity of fractures, etc.). Because all these factors can affect the rate of contaminant movement through aquifers, it can be very difficult to predict such movement. Groundwater in both WBZ1 and WBZ2 flows toward the LVR. In addition, vertical movement of groundwater from WBZ1 to WBZ2 (in addition to horizontal flow) is likely to influence contaminant migration from WBZ1 to WBZ2.

No contaminants were detected during air sampling performed during the OU2 RI. For health and safety purposes, air screening for volatile compounds was conducted using a PID during all soil and

groundwater sampling activities. Ambient air samples were collected from areas where asbestos was detected during the RI. ABS was conducted to estimate worker exposure to asbestos materials in soils and solids. Additionally, personal and perimeter air samples were collected to evaluate whether asbestos fibers were released into the air during ABS.

The contaminants of interest detected in surface water at OU2 at concentrations exceeding the SWSVs include metals (total and dissolved) and pesticides. Surface water may become contaminated through atmospheric deposition, surface water runoff, and groundwater discharge to surface water bodies. The surface water features at OU2 are located in areas of low elevation and fed primarily by surface water runoff. Surface runoff water can erode soil (including slag and debris material) and transport soil particles in suspension as overland flow for deposition at a lower elevation or to receiving waters, such as the surface water features at OU2 and the LVR. Surface runoff water also can transport dissolved-phase compounds from contaminated soils and solids to receiving waters as a nonpoint source of pollution. Another potential mechanism for volatile contaminant migration in surface water is diffusion. However, diffusion rarely is a dominant transport mechanism unless the water is stagnant.

9.3 HUMAN HEALTH RISK ASSESSMENT SUMMARY

This OU1 HHRA evaluated the potential exposure of human receptors to constituents detected in environmental media at the Matthiessen and Hegeler Zinc Company Site. The objectives of the HHRA were to evaluate whether site-related constituents detected in environmental media pose unacceptable risks to current and future human receptors and to provide information to support decisions concerning the need for further evaluation or action based upon current and reasonably anticipated future land use. In some instances, future land use scenarios that are not reasonably anticipated were assumed and quantitatively evaluated in this HHRA to support the evaluation of risk management measures during the FS.

The following sections summarize the Matthiessen and Hegeler Zinc Company Site HHRA as it applies to OU1, OU2, and the overall Site.

9.3.1 OU1 Summary

The following sections include HHRA summaries and conclusions for OU1 groundwater, Plant Area, Slag Pile Area, the LVR, and overall OU1 HHRA conclusions.

9.3.1.1 Groundwater

There are no groundwater supply wells at OU1 and groundwater is not used for potable or industrial uses, including irrigation. An ordinance of the City of LaSalle in conjunction with a MOU between the City and IEPA legally prohibits the drilling of water wells at OU1 for the purpose of obtaining a water supply. However, hypothetical future pathways assuming groundwater consumption were evaluated to provide risk managers with quantitative risk calculations to support the evaluation of risk management measures regarding groundwater use at OU1. If this pathway was complete, applying US EPA HHRA guidance, the calculated cancer and non-cancer risk estimates from groundwater consumption (and thus total receptor risks) would exceed US EPA's acceptable risk limits (i.e., cancer risks greater than 1×10^{-4} and non-cancer HIs greater than 1) for future commercial/industrial workers at the Carus Plant and Slag Pile, and hypothetical future residents at the Carus Plant. In the case of future commercial/ industrial workers, the unacceptable cancer risk (i.e., cancer risk greater than 1×10^{-4}) is entirely attributable to the assumption of future groundwater consumption; if that assumption is eliminated, consistent with existing law, then the calculated cancer risk estimate for future commercial/industrial workers would be within US EPA's acceptable risk range (i.e., between 1×10^{-4} and 1×10^{-6}). However, as described below, total receptor HIs for future commercial/industrial workers would still exceed 1. For the assumed residential scenario, calculated cancer and non-cancer risks exceed the acceptable risk range based on groundwater consumption as well as exposure to soil and homegrown produce. In addition, the maximum groundwater concentration of lead exceeded the Federal MCL; thus, potable use of groundwater, if it was allowed, has the potential to result in adverse effects to relevant receptors.

9.3.1.2 Plant Area

Under current conditions, there is no residential use of the Carus Plant Area and none is reasonably anticipated given the long industrial use of the property, zoning, and other factors making residential redevelopment of the property unlikely. As with groundwater use, hypothetical future residential land use of the Carus Plant Area was assumed to provide information for the evaluation of risk management decisions during the FS. Applying the US EPA HHRA methodology, residential use scenarios would predict RME and CTE cancer risks above US EPA's acceptable risk limits and also RME and CTE non-cancer HIs greater than 1 based on exposure to soils and homegrown produce. As noted above, unacceptable cancer and non-cancer risks estimates were also calculated for the hypothetical residential RME and CTE groundwater exposure scenarios at the Carus Plant Area.

At the Carus Plant EA, under RME and CTE assumptions and applying US EPA HHRA guidance, cancer risks were within US EPA's acceptable risk range for current commercial/industrial workers, current and future utility workers, and future construction workers. As discussed more fully above, the potential RME cancer risk exceeded the acceptable risk range for future commercial/industrial workers (due to assumed groundwater consumption); however, potential CTE cancer risks were within US EPA's acceptable risk range for future commercial/industrial workers. Aside from groundwater consumption, arsenic, hexavalent chromium (calculated from total chromium), Aroclor 1245, Aroclor 1260, and benzo(a)pyrene were the primary cancer risk drivers in soil. However, it should be noted that risks from Aroclor 1254, Aroclor 1260, and benzo(a)pyrene were calculated based on maximum detected concentrations due to their infrequent detection at the Carus Plant Area. Cancer risks to current and future commercial/industrial workers are also likely biased high due to the inclusion of samples currently under pavement in the risk assessment dataset.

Non-cancer RME and CTE HIs exceeded 1 for all receptor-exposure scenarios evaluated at the Carus Plant Area. Aside from the groundwater consumption scenarios, manganese and, to a lesser extent, mercury in soil were the primary non-cancer risk drivers. However, it should be noted that risks from total manganese are driven by a single sample collected in the 1990s in surficial soil. Also note, total mercury was simultaneously evaluated as inorganic and elemental mercury, thus, overestimating risks from mercury. Based on the assumption that all mercury in groundwater was volatile (i.e., present as elemental mercury), inhalation of mercury vapors from groundwater in trench air also contributed to overall non-cancer risks to utility and construction workers. Non-cancer risks to current commercial/industrial workers are also likely biased high due to the inclusion of samples currently under pavement in the risk assessment dataset.

Potential risks from exposure to lead were characterized by comparing the lead EPC in soil to a receptor-specific PRG. For construction and utility worker exposure scenarios, the maximum detected concentration was used as the EPC for lead. For all other exposure scenarios, the average concentration was used as the EPC for lead. There is a potential for adverse effects from exposure to lead in soil under an RME scenario for hypothetical future residents (surface soil only) and construction workers (subsurface soil); for hypothetical future residents there is also a potential for adverse effects from exposure to lead under a CTE scenario. As discussed above, maximum concentrations of lead in groundwater exceeded the Federal MCL, which could pose a risk if future groundwater consumption is assumed. Receptor-specific lead PRGs were not exceeded for any other exposure scenarios at the Carus Plant.

9.3.1.3 Slag Pile Area

At the Slag Pile EA, under RME assumptions and applying US EPA HHRA guidance, cancer risks were within US EPA's acceptable risk range for current and future site-specific workers, current and future utility workers, future construction workers, current and future trespassers, and future recreationalists. Potential RME cancer risk exceeded the acceptable risk range for future commercial/industrial workers (due to assumed groundwater consumption). Under CTE assumptions and applying US EPA HHRA guidance, cancer risk were below US EPA's acceptable risk range future construction workers, current and future trespassers, and future adolescent and adult recreationalists, and within US EPA's acceptable risk range for current and future site-specific workers, current and future utility workers, and future child recreationalists. Potential CTE cancer risk exceeded the acceptable risk range for the future commercial/industrial worker scenario (driven by assumed groundwater consumption). When soil exposure scenarios predicted cancer risks within US EPA's acceptable risk range, arsenic was the primary risk driver. Hexachlorobenzene and benzo(a)pyrene also contributed cancer risks greater than 1×10^{-6} for certain scenarios; however, these risk estimates were based on maximum detected concentrations due to the infrequent detection of these constituents at the Slag Pile Area. Assumptions regarding arsenic bioavailability in slag may also have overestimated potential arsenic risks from soil exposure.

RME and CTE HIs were less than 1 for current and future site-specific workers, current and future trespassers, and future recreationalists. The HI for current and future utility workers exceeded 1 under RME assumptions due to the presence of various metals in soil, but was less than 1 under CTE assumptions. Even though future redevelopment of the Slag Pile is unlikely, exposure scenarios for future commercial/industrial workers and future construction workers were evaluated; these scenarios resulted in non-cancer RME and CTE HIs greater than 1. For future commercial/industrial workers, non-cancer risks were primarily driven by the assumed consumption of groundwater; however, soil RME and CTE HIs also exceeded 1. Non-cancer risks to future construction workers were driven by the presence of various metals in soil and, to a lesser extent, the inhalation of (assumed elemental) mercury in trench air. When soil exposures exceeded 1, manganese was the primary non-cancer risk driver at the Slag Pile Area.

Potential risks from exposure to lead were characterized by comparing the lead EPC in soil to a receptor-specific PRG. For construction and utility worker exposure scenarios, the maximum detected concentration was used as the EPC for lead. For all other exposure scenarios, the average lead concentration was used as the EPC for lead. There is a potential for adverse effects from exposure to lead in soil under RME and CTE scenarios for future commercial/industrial workers, current and future utility

workers, future construction workers, and future child recreationalists. The maximum concentrations of lead in groundwater exceeded the Federal MCL, which could pose a risk if future groundwater consumption is assumed.

9.3.1.4 Little Vermilion River

At the LVR EA, under RME assumptions and applying US EPA HHRA guidance, cancer risks were below US EPA's acceptable risk range (for adolescent anglers, child fish consumers, and adolescent fish consumers) or within that range (for adult anglers and adult fish consumers). Under CTE assumptions, cancer risks were below 1×10^{-6} for all receptor-exposure scenarios evaluated. When predicted cancer risks were within US EPA's acceptable risk range, arsenic was the primary risk driver.

Non-cancer RME HIs were less than 1 for adolescent and adult anglers, and adolescent and adult fish consumers. The non-cancer HI exceeded 1 for child fish consumers. Mercury, assumed to be methyl mercury, was the primary contributor to the calculated non-cancer risk; however, mercury concentrations in the fillets collected from the LVR were within the range shown in the US EPA's National Study of Chemical Residues in Lake Fish Tissue (US EPA 2009f). No unacceptable non-cancer risks were shown for the CTE scenario.

9.3.1.5 Overall OU1 HHRA Conclusions

In summary, applying US EPA's HHRA guidance and RME assumptions, the OU1 HHRA shows that calculated cancer risks for current and reasonably anticipated future land use scenarios are within or below US EPA's acceptable risk range. Applying the same guidance, the OU1 HHRA calculated HIs greater than 1 for a number of exposure scenarios and assumptions, primarily due to the presence of metals in soil or slag, and in some cases due to the assumed presence of certain species of metals (i.e., elemental mercury and hexavalent chromium) in soil or slag.

When hypothetical future land uses allowing for groundwater consumption, which is contrary to current law, and/or residential use of the Carus Plant EA, which is not reasonably anticipated, were assumed, and US EPA HHRA guidance was applied, the OU1 HHRA resulted in calculated cancer and non-cancer risk estimates that exceed US EPA's acceptable limits.

9.3.2 OU2 Summary

Overall conclusions based on the risks and hazards detailed in the OU2 HHRA are summarized below.

- Potential risks exceeding US EPA's acceptable risk range were identified in EA2 (for the resident receptor), EA4 (for the commercial/industrial worker receptor), and EA6 (for the resident receptor) under RME conditions for both current and future land uses (and non-intrusive and intrusive scenarios). Under CTE conditions, potential risks for these EA-receptor combinations are within US EPA's acceptable risk range.
- The lowest risks and hazards are associated with EA3 and EA7. EA7 is the only EA with no significant risks or hazards.
- Potential exposure to COPCs in groundwater results in limited risks and hazards unless potable groundwater use is assumed.
- The greatest risks and hazards were identified for the commercial/industrial worker and the resident, and the lowest risks and hazards were identified for the adolescent and adult trespassers and the adolescent and adult recreationalists.
- Soil risks are driven by potential exposure to arsenic, benzo(a)pyrene (and other carcinogenic PAHs), Aroclor-1248, Aroclor-1260, and hexavalent chromium (for which risks likely are overstated).
- Soil hazards are driven by potential exposure to metals (primarily arsenic, cadmium, manganese, and zinc), cyanide (for which risks very likely are overstated; see Section 2.6.3.4 in Appendix RA), and Aroclor-1260 (primarily at EA4).
- Lead presents a potential risk to at least one receptor in all EAs except EA7. Lead poses potential risks to the following receptor types: construction worker (EA1 through EA6), commercial/industrial worker and child recreationalist (EA1, EA4, and EA5), and residents (EA6 at some locations).
- Asbestos presents potential risks to multiple receptors at EA1 and EA4 and presents no risks to any receptors at EA2, EA3, EA5, EA6, and EA7.

9.3.3 Site Summary

For the purposes of the RI, US EPA divided the Matthiessen and Hegeler Zinc Company Site into two OUs – OU1 and OU2. OU1 consists of the Carus Plant Area and areas to the east, including the Slag Pile Area, and the LVR. OU2 mainly consists of the former Matthiessen and Hegeler facility, but also includes an Off-site Residential Area and an Off-site Mixed Use Area. A set of receptors and exposure assumptions was developed for each OU to evaluate current and future risks within that OU. This risk assessment did not quantitatively consider potential risks for receptors exposed to more than one EA or to

both OUs. An evaluation was conducted to account for the possibility that a single receptor might have exposures that include both OU1 and OU2.

Because of the number of receptor-exposure pathways involved at each OU, there are numerous potential combinations. Some of these combinations are more relevant than others. Pathways associated with current residential (OU2) and industrial (OU1) receptors which may have secondary exposures while trespassing or recreating at other areas of the Site are the most appropriate to consider for this evaluation. Other scenarios are associated with a higher degree of uncertainty. For example, utility/construction workers are assumed to be exposed solely to the highest concentration point in each OU. As such, the calculated risks at each OU already represent a “worst case” scenario. Summing non-cancer risks to an individual receptor through time (e.g., from childhood resident to adult worker) is also problematic, as individual HQs are based on average daily intake, and thus, the non-cancer risk should simply be based on the most sensitive time.

Table RA-2-1 presents several potential cross-OU risk scenarios. These hypothetical risk scenarios focus on current workers at OU1 that may trespass at OU2, and current workers and residents at OU2 that may trespass or participate in recreational activities (including fishing and fish consumption) at OU1.

Generally, risks calculated for worker and residential scenarios were greater than those for trespassing or recreating. Thus, although additional on-site activities may contribute to overall risk, the increase in risk is modest.

9.4 ECOLOGICAL RISK ASSESSMENT SUMMARY

The purpose of an ERA is to evaluate the likelihood that adverse ecological effects are occurring or may potentially occur as a result of the site-specific constituent concentrations in environmental media. The ERA conservatively characterized ecological risks potentially associated with the Matthiessen and Hegeler Zinc Company Site under non-remediated (i.e., baseline) conditions. The ERA was performed in accordance with the US EPA ERAGS (1997a) eight-step process.

The following sections summarize the Matthiessen and Hegeler Zinc Company Site ERA as it applies to OU1, OU2, and the overall Site.

9.4.1 OU1 Summary

The primary objective of the SLERA was to evaluate, for each ecological EA, whether a more detailed ERA (i.e., a BERA) was warranted. The OU1 SLERA supports the following conclusions and recommendations:

- Concentrations of several constituents, primarily metals, in surface soil at the Carus Plant exceed SLERA ESVs for terrestrial wildlife receptors. However, the Carus Plant does not offer suitable ecological habitat due to the significant physical alterations to the landscape. Therefore, this is an incomplete exposure pathway and further evaluation in a BERA is not warranted.
- Concentrations of several constituents, primarily metals, in surface soil at the Slag Pile exceed SLERA ESVs for terrestrial wildlife receptors. Limited vegetation and wildlife receptors have been observed at the Slag Pile; however, the physical substrate, slag, creates a poor habitat for ecological receptors. The results of the phytotoxicity tests also support the SLERA results that constituents in Slag Pile soil have the potential to adversely affect ecological receptors. Therefore, additional ecological evaluation in a BERA is not recommended as it will not significantly refine risk estimates. Therefore, further evaluation in a BERA is not warranted.
- Concentrations of several constituents, primarily metals, in the sediment and surface water of the LVR exceed SLERA ESVs for benthic and aquatic receptors. The LVR is the most ecologically valuable habitat associated with the Site. Therefore, further evaluation in a BERA is recommended for this riverine/riparian habitat.

As described above, ecological risks associated with the terrestrial portions of the Site (i.e., the Carus Plant and the Slag Pile) did not warrant further evaluation in a BERA. Carus prepared a BERA to further characterize potential ecological risks in the LVR.

The OU1 BERA focused on potential risks associated with ecological exposure to the sediment, surface water, and biota in the LVR adjacent to the Matthiessen and Hegeler Zinc Company Site. The BERA included a refined analysis of COPECs (arsenic, cadmium, copper, lead, mercury, silver, and zinc) that compared location-specific concentrations in sediment and surface water to risk-based ESVs. However, the BERA focused on using more site-specific approaches (i.e., measurement endpoints) to characterize ecological effects to selected AEs. AEs evaluated in the BERA were as follows: mammals, avians, benthic macroinvertebrates, and fish. Risks to mammalian and avian receptors were evaluated using FCMs and biotic and abiotic data collected from the Site. Risks to benthic invertebrates were evaluated using toxicity testing and a community assessment. Risks to aquatic (fish) receptors were also evaluated

using a community assessment. When possible, Site data for benthic invertebrates and fish were compared to an upstream reference reach not affected by Site activities.

In accordance with US EPA guidance, the BERA combined each line of evidence (measurement endpoint results) through a process of weighing the evidence to characterize the overall status of the ecological community in the LVR. Based on the weight-of-evidence, the BERA supports the following specific conclusions:

- No unacceptable risks were identified for mammalian receptors (represented by the mink) for exposure to sediment, surface water, and biota of the LVR. LOAEL HQs were less than 1 for all COPECs evaluated in the BERA.
- The FCM for the belted kingfisher resulted in a LOAEL HQ of 1.7 for zinc, which under the BERA methodology indicates a potential for adverse effects to the growth and reproduction of avian receptors that feed/forage in the LVR adjacent to the Site. Calculated risks to the belted kingfisher were primarily driven by ingestion of zinc in mussel tissue; however, due to the uncertainties described previously (e.g., assumption of a diet consisting exclusively of fish and invertebrates from the Site, use of undepurated samples, use of the maximum field-measured biota concentrations, and use of laboratory-based effects estimates [TRVs]), this risk estimate may be biased high.
- The BERA FCMs predicted the potential for adverse ecological effects to individual avian receptors; however, given the conservative assumptions in the FCMs (exposure and effects estimates), and the lack of toxicity predicted for individual mammalian receptors, it is unlikely that the Site is adversely affecting populations of upper trophic level receptors that feed/forage along the LVR adjacent to the Site.
- The toxicity testing results combined with the more site-specific biological community assessment and resulting mIBI metrics indicated the benthic macroinvertebrate community was functioning and viable. The results of the acute toxicity testing using *C. dilutus* indicated that sediments at CAR001 may adversely affect the growth of macroinvertebrates; however, other site-related acute effects to the health of the macroinvertebrate community were not apparent. No statistically significant chronic effects on *H. azteca* survival or biomass were observed, and effects on weight were spatially limited and not co-located with effects observed in the acute test. The observed differences in the acute toxicity test results also cannot be correlated with chemical concentrations in Site sediments or surface water. In the macroinvertebrate community assessment, indices were indicative of a healthy and balanced macroinvertebrate community at

least comparable in biotic integrity to that expected for similar Illinois streams. Specifically, both east and west halves of the Site reaches attained mIBI scores ≥ 41.8 and MBI scores ≤ 5.9 , which were established as a BERA metrics for establishing potential risks to benthic macroinvertebrate communities.

- The biological community assessment and resulting fIBI metrics indicated the aquatic (fish) community is functioning and viable. The fIBI scoring from the fish community assessment indicates that all LVR reaches sampled, including the reference reach, are in IEPA Integrity Class 3 and scored in a very narrow range. Thus, it is reasonable to conclude that the ecological condition of the fish community in the LVR adjacent to the Site is not meaningfully different from the “background” conditions as measured at the same-stream reference reach. Further, all fIBI scores were ≥ 41 , which was established as a BERA metric for identifying potential risks to aquatic (fish) communities.
- The IEPA considers (along with other factors) the mIBI (or MBI) in conjunction with a fIBI in making assessments of designated use attainment in streams pursuant to the CWA. In that regulatory context, if a stream attains an mIBI score of ≥ 41.8 (or a MBI score ≤ 5.9 , if the mIBI is unavailable) combined with an fIBI score of ≥ 41 , the stream would be given a preliminary assessment that it is “Fully Supporting” of aquatic life use in Illinois streams. Under the CWA, IEPA equates the “Fully Supporting” terminology to a conclusion that a stream has “No Impairment” and is indicative of good resource quality (IEPA 2008a). While the BERA was conducted in a different regulatory context (i.e., under CERCLA), attainment of these values in all the Site reaches provides a line of evidence of the overall health of ecological community in the LVR.

Together, these lines of evidence provide support that the Site is not having a significant adverse effect on the overall health of the ecological community of the LVR. As indicated in the bullets above, some measurement endpoints suggest the possibility of limited impacts to the benthic community, but those effects, if any, are not consistently observed (e.g., no effects in the chronic toxicity tests) and are difficult to attribute to Site contaminants. The BERA methodology also calculated potential risks to current avian receptors; however, given the conservative assumptions and uncertainties associated with these risk estimates and lack of risks to mammalian receptors, risks to local populations of upper trophic level wildlife receptors are not anticipated. Thus, although the presence of slag material and municipal/industrial discharges in the vicinity of the sample reaches has the potential to affect ecological receptors in the LVR, the results of the BERA indicate the contrary. Risk management actions to reduce on-going contributions of contaminants from Site features to the LVR (e.g., erosion and storm water

runoff control for the Slag Pile and control of inputs from the ASO) would further reduce chemical concentrations and, thus, further mitigate potential ecological risks.

9.4.2 OU2 Summary

SulTRAC conducted both a SLERA and a BERA for the upland portion of OU2 consistent with US EPA ERA guidance (US EPA 1997a). As part of the risk assessment process, the following four major habitat areas were investigated at OU2: 1) Main Plant Area - highly disturbed (little or no vegetation), 2) adjacent to the main plant - disturbed with vegetation (woodland-grassland), 3) Savannah, and 4) Oak-Hickory Woodland. Maximum soil concentrations from each habitat area were compared to appropriate ESVs, and potential risks were investigated in each habitat. These potential risks were associated with metals, pesticides, PCBs, and PAHs. Based on this information, it was recommended that a BERA be performed in three of the habitat areas: 1) adjacent to the main plant - disturbed with vegetation (woodland-grassland), 2) Savannah, and 3) Oak-Hickory Woodland. Because of the poor quality of the habitat and high levels of contamination in the Main Plant Area, it was agreed that no BERA would be performed for this area.

The BERA evaluated potential exposures of plant, soil invertebrate, mammalian, and avian receptors in the three habitats. Site-specific information was obtained regarding the bioaccumulation of metals in above- and belowground portions of vegetation and the bioaccumulation of metals in earthworms in soils. In addition, soil toxicity was evaluated by collecting soil samples from each habitat and subjecting the soils to a seed germination and root and shoot elongation test. The soil EPCs were calculated for each habitat (the lower of the 95 percent UCL or the maximum concentration), and these data were used to assess potential risks to the various potential receptors. For plants and soil invertebrates, the EPCs were compared to plant- and soil invertebrate-specific SVs to assess potential risks. In addition, the soil toxicity and bioaccumulation test results also were evaluated as part of a weight-of-evidence evaluation. An FCM was used to assess potential risks to mammalian and avian receptors.

The BERA results identified potential risks in each of the three habitats evaluated as summarized below.

- The area adjacent to main plant found significant risks to the following receptors with the following risk drivers:
 - Plants: lead, mercury, selenium, and zinc
 - Soil invertebrates: chromium, mercury, and zinc

- Mammalian receptors
 - Herbivores: antimony, manganese, selenium, and zinc
 - Invertivores: antimony, selenium, and high molecular-weight PAHs
 - Omnivores: antimony and selenium
- Avian receptors
 - Herbivores: lead, mercury, and zinc
 - Invertivores: cadmium, lead, mercury, and zinc
 - Omnivores: lead mercury, selenium, and zinc
 - Carnivores: lead, mercury, and zinc

The soils also exhibited toxicity to both plants and earthworms based on the seed tests and mortality observed during the bioaccumulation tests, respectively.

- The Savannah area poses significant risks to the following receptors with the following risk drivers:
 - Plants: aluminum, chromium, lead, and zinc
 - Soil invertebrates: chromium and zinc
 - Mammalian receptors
 - Herbivores: zinc
 - Invertivores: zinc
 - Omnivores: zinc
 - Avian receptors
 - Herbivores: zinc
 - Invertivores: cadmium, lead, mercury, and zinc
 - Omnivores: zinc
 - Carnivores: zinc

The soils also exhibited toxicity to both plants and earthworms based on the seed tests and mortality observed during the bioaccumulation tests, respectively.

- The Oak-Hickory Woodland area located next to the LVR pose significant risks to the following receptors with the following risk drivers:
 - Plants: aluminum, chromium, and zinc
 - Soil invertebrates: chromium, mercury, and zinc

- Mammalian receptors
 - Herbivores: zinc
 - Invertivores: selenium
- Avian receptors
 - Herbivores: zinc
 - Invertivores: cadmium and zinc
 - Omnivores: zinc
 - Carnivores: zinc

The soils also exhibited toxicity to both plants and earthworms based on the seed tests and mortality observed during the bioaccumulation tests, respectively.

9.5 CONCLUSIONS

This section presents conclusions relative to the adequacy of the investigation, lists potential data gaps and uncertainties in the investigation, and potential future investigation recommendations.

9.5.1 Adequacy of the RI

The data developed for this RI is generally adequate to characterize the conditions present on Site with some limitations. Some data limitations and uncertainties remain with regard to investigation of specific areas of the Site or specific analytic parameters which may be addressed as part of the FS or subsequent remedial design. In some cases, data limitations and uncertainties have been addressed by adopting risk assessment assumptions that result in conservative determinations of risk for the pathways considered.

9.5.2 Data Limitations and Uncertainties

Tables 9.5.1-1 and 9.5.1-2, respectively, summarize potential uncertainties, data gaps, and potential future field investigation recommendations based on RI results for OU1 and OU2. The tables summarize the extent of delineation in each investigation area as well as uncertainties that may require additional information or refinement for each medium across each OU. These uncertainties may be addressed during future site work, including, but not limited to, the FS, pre-remedial design data collection, and remedial design implementation. Additional future sampling at and around OU2 may be necessary. Additional sampling may take place during the future FS, Remedial Design, and Remedial Action project phases.

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